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Mississippi Chemical Corporation has proposed to operate an open pit phosphate mine and beneficiation plant and rock dryer on 14850 acres in west central Hardee County, Florida. Mining and processing will produce 3 million tones of phosphate rock per year for 32 years. The EIS examines project alternatives, impacts, and mitigative measures related to air, groundwater, surface water, radiation, ecological, socioeconomic, and cultural systems.

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# Environmental Impact Statement

DRAFT

## Mississippi Chemical Corporation
## Hardee County Phosphate Mine
## Hardee County, Florida

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**Technical
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# TECHNICAL SUPPORT DOCUMENT I

# ALTERNATIVES

V

# TECHNICAL SUPPORT DOCUMENT I
## ALTERNATIVES

All project alternatives are presented in Section 2.0 of the Draft Environmental Impact Statement. A more detailed discussion of the rock drying alternative is presented in this TSD.

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# I.0 ROCK DRYING ALTERNATIVES

## 1.0 INTRODUCTION

### 1.1 BACKGROUND

The Central Florida Phosphate Industry Areawide Environmental Impact Assessment (USEPA, 1978) recommends that rockdrying be eliminated at beneficiation plants and that wet rock be transported to chemical plants for further processing. Rock to be used in triple superphosphate, elemental phosphorus, defluorinated rock feed, or other fertilizer processes requiring dry rock, could be dried at the chemical plant or at dryers permitted by the Florida Department of Environmental Regulation (DER) prior to publication of the Draft Areawide Draft EIS. The Areawide Final EIS allowed case-by-case considerations and for exceptions if the energy required for transporting wet rock outside of Florida for chemical processing were greater than the energy saved by eliminating drying and if air quality, including radioactive emissions, could be adequately protected.

Mississippi Chemical Company (MCC) currently processes dry rock into phosphoric acid and triple superphosphate at its Pascagoula plant. Therefore, MCC proposes to install a rock dryer at its new Hardee County mine. The dryer would be capable of drying all phosphate rock mined so that shipments of dry rock could be made both to Pascagoula and to customers which cannot accept wet rock. The actual amount of rock dried at the site would depend on the nature of the contracts made for shipment.

### 1.2 ALTERNATIVES

There are two practical alternatives to MCC's proposal; both would eliminate rock drying at the mine. These alternatives are:

1) Ship the rock wet; MCC dry it at the point of delivery.

2. Ship rock wet; MCC process it wet.

Actually, these two alternatives differ only in their effect on activities at MCC's Pascagoula plant. Since other customers for MCC's phosphate rock cannot be identified at this time, site-specific analyses cannot be made except in a general way. At Pascagoula, processing of wet rock would require substantial process changes from present dry rock processing.

## 1.3 ANALYSIS METHODOLOGY

The proposed action and alternatives were investigated for their effects on the following: energy use, air quality, land use, water quality, other environmental parameters. Technical feasibility and reliability, as well as capital investment and operating costs, were also considered. The analysis focuses on differences among alternatives. MCC's proposed action is addressed in Section 2.0; Alternative No. 1 (dry rock at point of delivery) and Alternative No. 2 (process wet rock) are treated in Sections 3.0 and 4.0, respectively. A comparison of alternatives is presented in Section 5.0.

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## 2.0 ROCK DRYER AT MINE (PROPOSED BY MCC)

### 2.1 DESCRIPTION OF PHOSPHATE ROCK HANDLING, TRANSPORTATION, AND PROCESSING SYSTEM

MCC proposes to install a fluidized bed dryer fired by No. 6 fuel oil at the beneficiation plant in Hardee County so that dry phosphate rock can be shipped to Pascagoula and to potential customers who can process only dry rock. The major rock handling activities for this alternative are shown on Figure I-1. The rock is mined, transported by pipeline in a slurry to the beneficiation plant, conveyed to various storage areas for drying and transfer to rail cars, transferred again to barges at Tampa, and then shipped to Pascagoula or other customers for grinding and chemical processing.

The rock handling facilities at the beneficiation plant would be suitable for shipping wet rock to customers who can accept it. However, for simplicity of presentation and to express worst case conditions at Ona, the proposed action is analyzed on the basis of drying all of the rock produced from the mine.

### 2.2 ENVIRONMENTAL CONSIDERATIONS

Expected environmental effects of the proposed action are described in the following sections. To facilitate a detailed comparison among alternatives, the effects are specified by handling activity. A summary comparison of the three alternatives is provided in Section 5.0.

### 2.2.1 Energy Use

Excluding energy used in facility construction, the major energy uses for the proposed rock handling system are listed in Table I-1. Since comparisons must be made for the complete chain of rock handling activities, all steps were considered for significant differences. From Table I-1, it is apparent that fuel oil to power the rock dryer is the major energy requirement (0.0743 bbl No. 6/ton rock, or 223,000 bbl/yr to dry the entire mine output). A significant amount of energy is also used for barge transport (0.0425 bbls/ton) and rock grinding

(0.0383 bbl/ton). Other energy uses, including transport by rail to Tampa, are relatively small. No estimates have been provided for rock mining, slurry piping, or beneficiation, as these are unaffected by rock dryer decisions. Also, no estimate is provided for energy use in normal chemical processing. As shown, the energy cost is approximately the same per ton for rock processed at Pascagoula as for rock shipped to other customers in the lower Mississippi River area. Rock shipped to closer or more distant ports would have energy requirements altered in proportion to barge transport distance.

### 2.2.2 Air Quality

The principal sources of air emissions from the proposed action are from the following operations:

1) Rock dryer;
2) Handling and storage of dry rock at the beneficiation plant, during transportation to the customer and during offloading on delivery; and
3) Rock grinding at Pascagoula (no change from present operations).

There are three general locations to be considered in assessing air quality effects of the rock drying system: (a) at the Ona mine and beneficiation plant site; (b) along rail and barge transportation routes between Ona and customer delivery; and (c) at the point of rock delivery (e.g., at Pascagoula for MCC).

In order to make a proper comparison of air quality effects of the various alternatives at Ona, emissions from the entire complex were analyzed. Details of the methodology, emission sources, and calculations of expected ground level concentrations are presented in Technical Support Document III. The principal results are shown in Table I-2. Rather substantial increases in ambient levels of $SO_2$ (3-hour, 24-hour, and annual averaging periods) and PM (24-hour averaging period) are predicted to occur. These increases will be well within allowable PSD increments (including allowance for interaction with other increment-consuming sources) and predicted ambient levels will be well below applicable ambient air quality standards (TSD-III). Other pollutants are expected to have no significant adverse impacts. Radionuclide dosages expected from plant emissions are given in TSD-V and Section 3.6 of the DEIS. The highest radium-226 concentration in the site vicinity is expected to be 3 percent above baseline concentrations; the maximum calculated individual dosage is less than 0.5 percent of that due to natural sources.

Along the transportation corridors between the MCC complex and point of rock delivery there will be fugitive emissions of particulates from the dry rock. No significant local or measurable regional effects should occur if barges and trucks are covered and particulate emissions are controlled at rock transfer points.

The proposed action would have no effect on current operations at Pascagoula, and should also have no effect at other points of delivery where dry rock is now received (Table I-3).

### 2.2.3 Other Environmental Considerations

#### 2.2.3.1 Land Use

It is estimated that 10 acres of land would be required at the beneficiation plant for dryer feed bins, rock dryer, and dry rock storage. No other facilities would be built as a result of the proposed action.

#### 2.2.3.2 Water Use and Quality

There would be no increase in water usage or liquid effluent at the mine site, beneficiation plant, or chemical plant as a result of the proposed action.

#### 2.2.3.3 Noise and Aesthetics

No significant adverse changes are expected in noise levels or visual aesthetics as a result of using a rock dryer at the mine.

## 2.3 TECHNICAL AND ECONOMIC CONSIDERATIONS

The proposal to dry phosphate rock at the mine for shipment to chemical processing facilities uses technology which is proven and accepted in the industry. MCC's Pascagoula fertilizer plant, and most other plants along the central Gulf coast where rock from MCC's mine is likely to be shipped, currently processes dry phosphate rock. Therefore, by following the proposed action, few new facilities would have to be constructed; process reliability would be a known factor; and MCC would have maximum flexibility to meet both present and future market demand for phosphate rock which must be sold to other customers in order to have an economically viable project.

The costs to construct and operate facilities for rock handling are listed in Table I-4. For the proposed system, the only significant capital investment is $12 million ($4/ton annual capacity) for the rock dryer at the mine. The most significant operating cost is $6.31/ton for port handling and barge transport. Investments required at other points of delivery cannot be determined.

There are no unusual reliability or safety problems due to employing a rock dryer. There is a potential for plant shutdown due to dryer or rock handling facility failure, but the risk is rather small because of the substantial storage of wet and dry rock to be provided at the beneficiation plant.

## 3.0 ROCK DRYER AT CHEMICAL PLANT (ALTERNATIVE NO. 1)

### 3.1 DESCRIPTION OF PHOSPHATE ROCK HANDLING, TRANSPORTATION, AND PROCESSING SYSTEM

This alternative assumes that rock drying is eliminated at the Hardee County Mine site. Wet rock would be loaded onto rail cars, transferred to barges, and shipped to Pascagoula (and to other customers), where it would be dried and processed in a manner similar to that planned in the proposed action. The major phosphate rock handling activities for this alternative are shown on Figure I-2.

### 3.2 ENVIRONMENTAL CONSIDERATIONS

#### 3.2.1 Energy Use

Energy use required to implement this alternative is summarized in Table I-5. As with the proposed system, the most significant energy uses are for barge transport (0.0478 bbl/ton), rock grinding (0.0383 bbl/ton), and rock drying (0.0743 bbl/ton). More energy is required per ton of rock handled than in the proposed system because 10 percent additional weight in moisture would be transported to Pascagoula before drying. The same rationale would apply to other customers who must dry the rock before processing.

#### 3.2.2 Air Quality

The sources of air emissions from Alternative No. 1 are similar to those of the proposed action. However, the rock dryer emissions would be at Pascagoula (or other delivery point) instead of in Florida. Also, there would be less particulate matter emitted from handling and transport of wet rock.

The principal results of the air quality analysis for Alternative 1 are shown in Tables I-2 and I-3 (see TSD-III for details). At the Ona Mine (Table I-2), elimination of the rock dryer and dry rock handling facilities would reduce emissions to the extent that only very minor effects on air quality would be predicted for the proposed mine and beneficiation plant. As a consequence, radionuclide emissions and population dosages would also be substantially reduced.

Fugitive emissions from rail and barge transportation would be reduced compared to those (unquantified, but relatively small with proper controls) for dry rock transport.

At Pascagoula, addition of a rock dryer (and associated small boiler) would produce significant increases in ambient concentrations of $SO_2$ but not PM or $NO_2$ (Table I-3). A PSD permit would be required to install this dryer. The potential for consumption of local PSD Class II $SO_2$ increments is exacerbated by possible interaction with the modification currently underway at an adjacent oil refinery which involves substantial emissions of $SO_2$. Effects on the Breton National Wilderness PSD Class I Area might also be restrictive. Radionuclide emissions from the rock dryer would also be produced; these emissions would be approximately one-third of those from the rock dryer for the proposed action at Ona Mine (see TSD-V). Radium-226 concentrations and annual population dosages due to the proposed action at Ona were estimated to be only a very small fraction of natural levels (Section 2.2.2).

### 3.2.3 Other Environmental Considerations

#### 3.2.3.1 Land Use

An estimated 12 acres would be required for facilities built specifically for this alternative. This includes 5 acres for wet rock handling and loading at the mine and 7 acres for wet rock unloading facilities at Pascagoula. Only about 1/3 acre would be required for the rock dryer at Pascagoula since dry rock transfer and storage facilities already exist.

#### 3.2.3.2 Water Use and Quality

There would be no change in water usage or liquid effluent at the mine site, beneficiation plant, or chemical plant as a result of implementation of this alternative. Existing dock facilities at Pascagoula would have to be expanded because of the reduced efficiency inherent in clam shell off-loading of wet rock; consequent dredging in Bayou Casotte would have temporary adverse effects on water quality.

### 3.2.3.3 Noise and Aesthetics

No significant adverse changes are expected in noise levels or visual aesthetics as a result of drying the rock at Pascagoula.

## 3.3 TECHNICAL AND ECONOMIC CONSIDERATIONS

This alternative substitutes rock drying at the chemical plant for drying at the Hardee County Mine site. Facilities would be required to store and handle wet rock at the beneficiation plant and at the point of rock delivery. A rock dryer and new wet rock handling and storage facilities would have to be built at Pascagoula. There are no technical difficulties associated with this alternative; process reliability is a known factor, and sufficient storage will be available to minimize the chance of plant shutdown resulting from dryer outage.

With this alternative, MCC would not have the flexibility of selling to customers who must use dry rock and do not have their own drying facilities. Currently, although approximately 43 percent of the phosphate rock produced in the southeastern U.S. enters the phosphoric acid process as wet rock, 93 percent of this rock is captive (i.e., mined by the same company which processes it). Also, only 8 percent of the wet rock grinding capacity is outside the producing area, and all of this is captive. Wet rock is not currently shipped in international trade. These data indicate that most noncaptive phosphate rock demand is for dry rock, rather than wet. It is likely that MCC would have difficulty finding customers for the 2 million tons of wet rock per year which must be sold to maintain an economically viable project.

Significant capital investments would be required for wet rock unloading, storage, and dryer facilities at Pascagoula ($13.4 million, or $13.4/ton). Operating costs would be similar in nature to those of the proposed alternative, though somewhat higher because of the need to transport moisture in the rock. The most significant operating cost is $7.12/ton for port handling and barge transport (Table I-6). No information can be provided on costs for customer facilities, except to assume similarity with MCC.

There are no unusual reliability or safety problems associated with employing a rock dryer at Pascagoula. Sufficient rock storage should be available to minimize the chances for plant shutdown should the dryer malfunction.

It should be noted that dock facility expansions required to handle wet rock delivery and unloading would require a dredge and fill permit from the U.S. Army Corps of Engineers. This adds an element of uncertainty, and potential for delay, to the project.

# 4.0 NO ROCK DRYER (ALTERNATIVE NO. 2)

## 4.1 DESCRIPTION OF PHOSPHATE ROCK HANDLING, TRANSPORTATION, AND PROCESSING SYSTEM

This alternative assumes that rock drying is eliminated both at the Hardee County site and at Pascagoula. Wet rock would be processed into phosphoric acid at the Pascagoula plant (and at other customer plants). Since there is currently no wet rock process available for producing triple superphosphate, MCC would have to purchase sufficient dry rock from other sources for this purpose. A schematic of the major phosphate rock handling activities for this alternative is shown in Figure I-3.

## 4.2 ENVIRONMENTAL CONSIDERATIONS

### 4.2.1 Energy Use

Energy use required to implement this alternative is summarized in Table I-7. The greatest amount of energy is used for processing wet rock into phosphoric acid. This total of 0.1907 bbl of fuel oil per ton of rock is the estimated increase in energy use caused by processing wet rock instead of dry rock. Most of this energy would be consumed as fuel oil in concentrating the lower strength of product back to 28 acid percent for downstream processing in existing facilities. The need for this concentration is explained as follows: Wet rock grinding requires approximately 180 gallons per minute (gpm) of slurry water in the grinding circuit in addition to the 60 gpm of excess water in the wet rock. In a typical Florida wet rock grinding operation, product phosphoric acid strength can be maintained by reducing recycle of pond water to the process by an amount equivalent to the volume of additional water added in the wet grinding circuit; this is possible because there is a net excess of evaporation over precipitation plus process consumption in Florida. At MCC's Pascagoula facility, however, there is an excess of precipitation over natural evaporation plus consumption. Thus, water must be treated and discharged to Bayou Casotte in order to maintain the required storage area surge capacity.

An existing NPDES permit regulates this discharge by placing concentration limits on phosphorus and fluorine, and a mass effluent limitation on nitrogen. Since the plant discharge is approaching this nitrogen limitation now, little additional discharge above current volumes can be tolerated.

As a result of this problem with water balance, MCC cannot adjust its product strength by reducing pond water recycle unless a new NPDES permit is issued to allow greater effluent discharge to Bayou Casotte. The alternative is to install new weak acid storage and evaporation facilities as well as new steam generation capacity. Production of the required 150,000 lbs/hour of 25 lb/in$^2$ steam would consume approximately 180,000 barrels of No. 6 fuel oil annually (Table I-7).

Other significant energy requirements for this alternative are 0.0478 bbls/ton for barge transport and 0.0315 bbls/ton for grinding. The total energy use attributable to this alternative is estimated at 0.2848 bbls/ton. No estimate can be given for energy use at other customer facilities as process changes are site specific.

### 4.2.2 Air Quality

For this alternative, all rock transported from the mine would be wet; therefore fugitive particulate emissions from rock drying and handling would be virtually eliminated. Relatively small quantities of dry rock would still be ground at Pascagoula for production of triple superphosphate. Additional steam capacity for phosphoric acid concentration at Pascagoula would require combustion of approximately 180,000 bbl of No. 6 fuel oil per year with consequent significant exhaust gas emissions.

Tables I-2 and I-3 summarize the results of air quality impact calculations (see TSD-III for details). As with Alternative 1, emissions of both $SO_2$ and PM (consequently, also radionuclides) would be greatly reduced at the Ona Mine (Table I-2), as well as along the rail and barge transportation routes. However, the large new boiler required at Pascagoula represents a significant source of $SO_2$, PM, and $NO_2$ emissions. Based upon an assumed fuel sulfur content of 2.0 percent by weight, estimated ambient increases in $SO_2$, PM, and $NO_2$ concentrations are listed in Table I-3. NAAQS would be met for all pollutants, but there is a potential PSD increment problem for $SO_2$ both in the surrounding Class II area and in the nearest Class I area (Breton Wilderness). Radionuclides emissions would be negligibly small with this alternative at Pascagoula.

A PSD permit would be required for installation of this boiler at Pascagoula. It is likely that either low sulfur fuel oil (less than 2 percent sulfur) or emission tradeoffs would be required to obtain permit approval.

### 4.2.3 Other Environmental Considerations

#### 4.2.3.1 Land Use

An estimated 12 acres would be required for facilities built specifically for this alternative. This includes 5 acres for wet rock handling and loading at the mine site and 7 acres for wet rock unloading and storage facilities at Pascagoula.

#### 4.2.3.2 Water Use and Quality

There would be no change in water usage or liquid effluent at the mine site, beneficiation plant, or chemical plant if this alternative is implemented as described. The present excess of water at the Pascagoula plant requires treatment and discharge under an existing NPDES permit. If the additional water introduced in the wet rock and for wet rock grinding is not evaporated as described in Section 4.2.1, it is estimated that pollutant loadings to Bayou Casotte would increase by 33,700 lbs/yr of phosphorus, 24,000 lbs/yr of fluorine, and 12,000 lbs/yr nitrogen (in ammonia). This would require a revised NPDES permit from the Mississippi Bureau of Pollution Control. Though a possibility, it is assumed for this analysis that such a permit revision would not be issued.

Existing dock facilities at Pascagoula would have to be expanded to accommodate delivery and unloading of both wet rock and the dry rock for TSP production; this would require dredging in Bayou Casotte and a permit from the U.S. Army Corps of Engineers. There would be a temporary adverse impact on water quality in Bayou Casotte due to dredging and dock construction.

#### 4.2.3.3 Noise and Aesthetics

No significant adverse changes are expected in noise levels or visual aesthetics as a result of shipping and processing wet rock for phosphoric acid production.

## 4.3 TECHNICAL AND ECONOMIC CONSIDERATIONS

This alternative substitutes wet rock processing for rock drying. In addition to building facilities for wet rock handling at the beneficiation and chemical plants, significant changes would be required in the Pascagoula phosphoric acid plant and downstream processing facilities (it is not known whether similar changes would be required for other customers). The additional water introduced into the process stream with the wet rock and for wet rock grinding can be handled without technical difficulties. A water balance problem is created, however, with consequent effects on energy use, cost, and/or water quality (see Section 4.2).

As with Alternative No. 1, this alternative requires that MCC market phosphate rock to customers who do not need dry rock. As described in Section 3.3, most wet rock processing is done at captive plants located in Florida. For at least the immediate future, this alternative would have a significant, adverse effect on MCC's market potential and flexibility.

As an additional technical consideration, a change to wet rock grinding eliminates any possibility for MCC adoption of the newly-developed hemihydrate phosphoric acid production processes at the Pascagoula plant. This new process technology has the advantage of increasing overall $P_2O_5$ recovery from 93 percent to 98 percent and significantly reducing energy use per ton of $P_2O_5$ produced.

Capital investments required to implement this alternative are substantial, as shown in Table I-8. These include $10.7 million for phosphoric acid facility modifications, $9 million for wet rock unloading and storage facilities, and $5.1 million for wet rock grinding; all of these facilities would be located in Pascagoula. Operating costs would also be substantial, totaling $17.98/ton of rock; the most significant of these are $6.04/ton for phosphoric acid processing and $7.12/ton for port handling and barge transport. Again, cost estimates cannot be made for other customers.

There are no unusual reliability or safety problems associated with processing wet rock at Pascagoula. Because of reduced ground rock storage quantities, there is expected to be a somewhat greater chance for plant shutdown due to wet rock grinder malfunction.

This alternative would require a Section 10 permit from the U.S. Army Corps of Engineers, adding an element of uncertainty and potential for delay to the project.

## 5.0 SUMMARY COMPARISON OF ALTERNATIVES

### 5.1 COMPARISON OF BASIC ALTERNATIVES FOR PASCAGOULA DELIVERY OF PHOSPHATE ROCK

A direct comparison of environmental impacts and technical considerations for the proposed action and the two basic alternatives described in Sections 2.0, 3.0, and 4.0 is provided in Table I-9. Because of the limited information available to describe impacts caused by rock deliveries to other customers, quantitative comparison is limited to consideration of delivery and processing of rock at MCC's Pascagoula plant.

Consider first the environmental and economic impacts of the proposed action. Energy use is lowest for the proposal to dry rock at the mine. Compared with Alternative No. 1, 13,000 barrels of No. 6 fuel oil (equivalent) are saved annually by eliminating the transportation of the additional moisture in the rock to Pascagoula; approximately 110,000 barrels are saved annually by not having to reconcentrate the phosphoric acid as required in Alternative No. 2. Both the capital investment and annual operating costs are also lower for the proposed system. Investment savings are $10.5 million compared to Alternative No. 1 and nearly $22 million compared to Alternative No. 2. Equally important, annual operating savings are nearly $2 million compared to Alternative No. 1 and $5.1 million compared to Alternative No. 2.

Air quality impacts can be divided into three geographic locations. At the Ona mine, both Alternatives 1 and 2 result in substantially lower emissions of $SO_2$, PM, and $NO_2$. Consequent effects on ambient air quality are substantially less. However, the proposed action is well within both PSD increments and ambient air quality standards.

Along the rail and barge transportation routes, both alternatives pose a substantially lower (but unquantifiable) potential for fugitive dust emissions. However, the proposed action should not exceed any air quality regulation nor should effects on ambient air quality be significantly adverse.

At Pascagoula, the proposed action would have no effect on present emissions or air quality. Both alternatives would cause substantial increases in $SO_2$ emissions and would require PSD permit approval. It is possible that PSD approval would not be obtained for Alternative 2 without commitment to low sulfur fuel oil or a substantial tradeoff of $SO_2$ emissions from other sources.

Approximately ten (10) acres are required for development of the proposed facilities; all of this land will be at the mine where land is readily available. Alternatives No. 1 and No. 2 both require approximately 12 acres (including 7 acres at Pascagoula), expansion of dock facilities at Pascagoula, and dredging in Bayou Casotte. The dredging will introduce silt into the water column and possibly resuspend certain pollutants presently confined to the channel bottom. Though these water quality effects will be temporary, a Section 10 permit will be required from the U.S. Army Corps of Engineers before such construction can take place.

Technical considerations which are of concern in the choice among rock drying alternatives are the possibility for plant shutdown due to decreased system reliability and the effect on marketing phosphate rock to other customers. As indicated in Table I-9, there is some increase in potential for plant shutdown with Alternative No. 2 because of the wet rock grinding process. However, the most significant factor is the lack of a ready market for wet rock. Wet rock is not currently shipped overseas, and most wet rock processing is done at captive chemical plants in Florida. MCC would have difficulty marketing 2 million tons of wet rock annually, as they must if no rock dryer is constructed at Ona.

## 5.2 COMPARISON OF ALTERNATIVES FOR DELIVERY TO OTHER CUSTOMERS

As indicated previously, the effects of rock dryer system selection on environmental and technical considerations associated with shipment of rock to other customers cannot be completely evaluated. For customers who require dry rock for fertilizer production, it is reasonable to assume that similar energy usage may be required per ton of rock handled, particularly if the point of rock delivery is on the central Gulf coast (as assumed in Tables I-1 and I-5). In this case, approximately 26,000 barrels of oil per year would be saved by the proposed action in comparison with Alternative No. 1. Greater savings would be realized with points of delivery at a greater distance from the mine. No such comparison can be made with alternative No. 2 because energy requirements associated with process changes are very site-specific (if no substantial process changes are required, there could be an energy savings, see Tables I-1 and I-7).

If customers could be found for wet rock, energy savings would be as much as 0.08 bbl of fuel oil per ton of rock delivered, compared to drying the rock. This is 160,000 bbl of oil savings potential annually for the 2 million tons of rock sold to other customers.

A comparison of system economic costs cannot reasonably be made among alternatives for other customers because facility requirements may vary substantially at the point of delivery. Certainly, omission of a rock dryer at the mine would reduce investment and operating costs for MCC with Alternatives No. 1 and No. 2. There is also less "value-added," however, and consequently, a lower price must be charged for wet rock. Rail and barge transport costs are lower for dry rock in proportion to the reduced weight of the product. No estimate can be given for costs incurred by the customer at the point of rock delivery and processing; these would likely be substantially greater for Alternatives No. 1 and No. 2 if dry rock is required, as expected.

Air quality effects at the sites of other phosphate rock customers would not likely be any worse than those expected at Pascagoula. If there are no other sources in the immediate area which consume PSD increments and, especially, if no new steam generating capacity is required to concentrate the phosphoric acid stream, then air quality effects may be no worse than expected at Ona with the proposed action.

If wet rock were to be processed, air quality effects would be negligible.

Nothing of a definitive nature can be said to compare land use, water quality, reliability, or other aspects of rock delivery to other customers. These depend primarily on existing facilities and process changes required at the receiving site.

## 5.3 SUMMARY

To summarize the alternatives available to a rock dryer at the proposed MCC Ona mine site, it is helpful to consider the following basic courses of action available:

| Permit Decision | Ona Processing | Fertilizer Plant Processing |
|---|---|---|
| I. Allow Rock Dryer at Ona | A. Dry All Rock | 1. MCC Process Dry Rock |
| II. Disallow Rock Dryer at Ona | B. Dry Only MCC Rock | 2. Customers Process Dry Rock |
| | C. Ship All Rock Wet | 3. Customers Dry Rock |
| | | 4. Customers Process Wet Rock |
| | | 5. MCC Dry Rock at Pascagoula |
| | | 6. MCC Process Wet Rock at Pascagoula |

The combinations of feasible options are shown in Figure I-4. Alternatives which have been considered in detail include all possible courses of action open to MCC (highlighted in Figure I-4):

| | |
|---|---|
| I-A-1 (same as I-B-1) | Proposed Action |
| II-C-5 | Alternative 1 |
| III-C-6 | Alternative 2 |

Courses of action open to other customers have, for the most part, been discussed qualitatively as sufficient information is not available for detailed treatment.

Considering the options open to MCC for rock shipped to Pascagoula, the proposed action appears to be superior in terms of energy use, economics, air quality, land use, and marketing potential. If customers can be found which will process wet rock, it would be best to ship wet rock to them. Such customers are not expected to be found in the near future. However, MCC has committed to identifying wet rock customers and shipping maximum quantities of wet phosphate rock.

It is probable that during the life of Ona Mine, if a rock dryer is permitted, there will be a stepwise shift from an initial I-A scenario toward a I-B scenario; that is, MCC would dry all of the rock sent to Pascagoula for the foreseeable future but would gradually dry less of the rock shipped to other customers, as new (or converted) plants which can process wet rock are developed.

# TABLE I-1

# ENERGY USE FOR PROPOSED ACTION - ROCK DRYER AT MINE SITE

| Activity | Calculation | Energy Use (Bbl No. 6 Fuel Oil[a]/ton "bone dry rock") | |
|---|---|---|---|
| | | Pascagoula[b] Delivery | Other Customer[c] Delivery |
| Mining | No difference among alternatives | --- | --- |
| Beneficiation | No difference among alternatives | --- | --- |
| Wet Rock Storage | No difference among alternatives | --- | --- |
| Dryer Feed Bins, Rock Dryer, Dry Rock Storage and Loading at Mine | (1) Electrical: ($12.5 \times 10^6$ kwh/yr x 1466 bbl[d]/$10^6$ kwh) ÷ $3 \times 10^6$ tons/yr<br>(2) Fuel Oil: 223,000 bbl/yr ÷ $3 \times 10^6$ tons/yr | 0.0061<br>0.0743 | 0.0061<br>0.0743 |
| | Subtotal | 0.0804 | 0.0804 |
| Rail Transport | (700 Btu[e]/ton-mile x 60 miles) ÷ (151,000 Btu/gal x 42 gal/bbl) ÷ 0.98[f] | 0.0068 | 0.0068 |
| Barge Transport | (600 Btu[g]/ton-mile x 440 miles) ÷ (151,000 Btu/gal x 42 gal/bbl) ÷ 0.98[f] | 0.0425 | 0.0425[h] |
| Rock Unloading and Storage | ($1.09 \times 10^6$ kwh/yr x 1466 bbl/$10^6$ kwh) ÷ $1 \times 10^6$ tons/yr | 0.0016 | 0.0016[i] |
| Rock Grinding | ($26.1 \times 10^6$ kwh/yr x 1466 bbl/$10^6$ kwh) ÷ $1 \times 10^6$ tons/yr | 0.0383 | 0.0383[i] |
| Processing into Phosphoric Acid and Triple Superphosphate | Base case - no estimate provided | --- | --- |
| Total | | 0.1757 | 0.1757 |

---

[a] Energy use is expressed in terms of No. 6 fuel oil for comparison purposes. No. 6 fuel oil has an energy content of 151,000 Btu/gal.

[b] Assumed to be 1,000,000 tons/year "bone dry" or 1,020,000 tons/year "dry" (2 percent moisture).

[c] Assumed to be 2,000,000 tons/year "bone dry" or 2,040,000 tons/year "dry" (2 percent moisture).

TABLE I-1 (Continued)

[d] Assumes 36.7 percent energy conversion efficiency for electric power generating facilities.

[e] An average based on the following references  Congressional Research Service, 1977, Bevilacqua, 1978; Mays and others, 1976; Goodson, 1976; Eldridge and Van Gorp, 1980; and Charles River Associates, Incorporated, 1980.

[f] Conversion from tons "dry" to tons "bone dry."

[g] An average based on the following references: Congressional Research Service, 1977; Bevilacqua, 1978; Goodson, 1976; Eldridge and Van Gorp, 1980; and Charles River Associates, Incorporated, 1980.

[h] Based on distance to mouth of Mississippi River, which is approximately 440 miles.

[i] Assumed same as at Pascagoula plant.

TABLE 1-2

COMPARISON OF PREDICTED GROUND-LEVEL CONCENTRATIONS FOR CRITERIA POLLUTANTS EMITTED BY THE MCC COMPLEX AT ONA[a]

| | | Concentrations (μg/m³) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Proposed Action | | Alternative 1 | | Alternative 2 | |
| Pollutant | Averaging Time | State of Florida Standard | Class II PSD Increment | Calculated Maximum PSD Consumption | Calculated Maximum Ambient Concentration | Calculated Maximum PSD Consumption | Calculated Maximum Ambient Concentration | Calculated Maximum PSD Consumption | Calculated Maximum Ambient Concentration |
| Sulfur Dioxide | 3-Hour | 1,300 | 512 | 158 | 315 | b | 166 | b | 166 |
| | 24-Hour | 260 | 91 | 41 | 110 | b | 71 | b | 71 |
| | Annual Arithmetic Mean | 60 | 20 | 6 | 10 | b | 4 | b | 4 |
| Particulate Matter | 24-Hour | 150 | 37 | 16 | 106 | b | -- | b | -- |
| | Annual Arithmetic Mean | 60 | 19 | 2 | 30 | b | -- | b | -- |

---

[a] Concentrations of carbon monoxide and nitrogen doixide attributable to MCC emissions have been calculated but are negligible for the proposed action and each alternative.

[b] Below USEPA significant impact levels.

## TABLE I-3

## COMPARISON OF PREDICTED GROUND-LEVEL CONCENTRATIONS FOR CRITERIA POLLUTANTS EMITTED BY THE PASCAGOULA FACILITIES[a]

| | | Concentrations ($\mu g/m^3$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Proposed Action | | Alternative 1 | | Alternative 2 | |
| Pollutant | Averaging Time | NAAQS | Class II PSD Increment | Calculated Maximum PSD Consumption | Calculated Maximum Ambient Concentration | Calculated Maximum PSD Consumption | Calculated Maximum Ambient Concentration | Calculated Maximum PSD Consumption | Calculated Maximum Ambient Concentration |
| Sulfur Dioxide | 3-Hour | 1,300 | 512 | -- | -- | 150[b] | 450 | 260[b] | 550 |
| | 24-Hour | 365 | 91 | -- | -- | 40[b] | 150 | 85[b] | 200 |
| | Annual Arithmetic Mean | 80 | 20 | -- | -- | 5[b] | 25 | 10[b] | 30 |
| Particulate Matter | 24-Hour | 260 | 37 | -- | -- | c | -- | c | -- |
| | Annual Arithmetic Mean | 75 | 19 | -- | -- | c | -- | c | -- |

---

[a] Concentrations of carbon monoxide and nitrogen dioxide attributable to MCC emissions have been calculated but are negligible for the proposed action and each alternative.

[b] Attributable to MCC emissions alone; does not include possible interaction with other sources.

[c] Below USEPA significant impact levels

## TABLE I-4

## ECONOMIC COSTS OF PROPOSED ACTION - ROCK DRYER AT MINE

Page 1 of 2

| | Capital Costs[a] | | Annual Operating Costs[a] | |
|---|---|---|---|---|
| Activity | Pascagoula Delivery | Other Customer Delivery | Pascagoula Delivery | Other Customer Delivery |
| Mining[b] | -- | -- | -- | -- |
| Beneficiation[b] | -- | -- | -- | -- |
| Wet Rock Storage[b] | -- | -- | -- | -- |
| Dryer Feed Bins, Rock Dryer, Dry Rock Storage and Loading at Mine | 4.00 | 4.00 | 2.27 | 2.27 |
| Rail Transport | 0.00 | 0.00 | 2.29 | 2.29 |
| Barge Transport and Port Handling[c] | 0.00 | 0.00 | 6.31 | 6.31 |
| Rock Unloading and Storage | 0.00 | d | 0.58 | d |
| Rock Grinding | 0.00 | d | 1.40 | d |
| Processing into Phosphoric Acid and Triple Superphosphate | e | d | e | d |
| Total | 4.00 | d | 12.85 | d |

TABLE I-4 (Continued)

Page 2 of 2

[a] Expressed as 1980 dollars/ton annual capacity "bone dry;" rock assumed to contain 2 percent moisture after rock drying.

[b] No difference among alternatives.

[c] Includes $1.74/ton "bone dry" port handling and $4.57/ton "bone dry" barge transport.

[d] Costs dependent on customers and existing equipment; cannot be determined.

[e] Base case; no estimate provided.

# TABLE I-5

## ENERGY USE FOR ALTERNATIVE NO. 1 - ROCK DRYER AT CHEMICAL PLANT

Page 1 of 2

| Activity | Calculation | Energy Use (Bbl No. 6 fuel oil[a]/ton "bone dry" rock) | |
|---|---|---|---|
| | | Pascagoula[b] Delivery | Other Customer[c] Delivery |
| Mining | No difference among alternatives | --- | --- |
| Beneficiation | No difference among alternatives | --- | --- |
| Wet Rock Storage | No difference among alternatives | --- | --- |
| Wet Rock Loading | $(1.05 \times 10^6$ kwh/yr $\times$ 1466 bbld/$10^6$ kwh) $\div 3 \times 10^6$ tons/yr | 0.0005 | 0.0005 |
| Rail Transport | (700 Btu[e]/ton-mile × 60 miles) ÷ (151,000 Btu/gal × 42 gal/bbl) ÷ 0.87[f] | 0.0076 | 0.0076 |
| Barge Transport | (600 Btu[g]/ton-mile × 440 miles) ÷ (151,000 Btu/gal × 42 gal/bbl) ÷ 0.87[f] | 0.0478 | 0.0478[h] |
| Wet Rock Unloading and Storage | $(3.99 \times 10^6$ kwh/yr $\times$ 1466 bbl/$10^6$ kwh) $\div 1 \times 10^6$ tons/yr | 0.0058 | 0.0058[i] |
| Dryer Feed Bins, Rock Dryer, Dry Rock Storage at Pascagoula | (1) Electrical: $(10.23 \times 10^6$ kwh/yr $\times$ 1466 bbl/$10^6$ kwh) $\div 1 \times 10^6$ tons/yr<br>(2) Fuel Oil: 74,300 bbl/yr $\div 1 \times 10^6$ tons/yr | 0.015<br>0.0743 | 0.015[i]<br>0.0743[i] |
| | Subtotal | 0.0893 | 0.0893 |
| Rock Grinding | $(26.1 \times 10^6$ kwh/yr $\times$ 1466 bbl/$10^6$ kwh) $\div 1 \times 10^6$ tons/yr | 0.0383 | 0.0383[i] |
| Processing into Phosphoric Acid and Triple Superphosphate | Base case - no estimate provided | --- | --- |
| Total | | 0.1893 | 0.1893 |

---

[a] Energy use is expressed in terms of No. 6 fuel oil for comparison purposes. No. 6 fuel oil has an energy content of 151,000 Btu/gal.

[b] Assumed to be 1,000,000 tons/year "bone dry" or 1,149,000 tons/year "wet" (13 percent moisture).

[c] Assumed to be 2,000 000 tons/year "bone dry" or 2,299,000 tons/year "wet" (13 percent moisture).

TABLE I-5 (Continued)

Page 2 of 2

[d] Assumes 36.7 percent energy conversion efficiency for electric power generating facilities.

[e] An average based on the following references: Congressional Research Service, 1977; Bevilacqua, 1978; Mays and others, 1976; Goodson, 1976; Eldridge and Van Gorp, 1980; and Charles River Associates, Incorporated, 1980.

[f] Conversion from tons "wet" to tons "bone dry."

[g] An average based on the following references: Congressional Research Service, 1977; Bevilacqua, 1978; Goodson, 1976; Eldridge and Van Gorp, 1980; and Charles River Associates, Incorporated, 1980.

[h] Based on distance to mouth of Mississippi River, which is approximately 440 miles.

[i] Assumed same as at Pascagoula plant.

## TABLE I-6

## ECONOMIC COSTS OF ALTERNATIVE NO. 1 - ROCK DRYER AT CHEMICAL PLANT

Page 1 of 2

| Activity | Capital Costs[a] |  | Annual Operating Costs[a] |  |
|---|---|---|---|---|
|  | Pascagoula Delivery | Other Customer Delivery | Pascagoula Delivery | Other Customer Delivery |
| Mining[b] | -- | -- | -- | -- |
| Beneficiation[b] | -- | -- | -- | -- |
| Wet Rock Storage[b] | -- | -- | -- | -- |
| Wet Rock Loading at Mine | 1.13 | 1.13 | 0.23 | 0.23 |
| Rail Transport | 0.00 | 0.00 | 2.57 | 2.57 |
| Barge Transport and Port Handling[c] | 0.00 | 0.00 | 7.12 | 7.12 |
| Rock Unloading and Storage | 9.00 | d | 0.74 | d |
| Dryer Feed Bins, Rock Dryer, Dry Rock Storage at Pascagoula | 4.40 | d | 2.70 | d |
| Rock Grinding | 0.00 | d | 1.40 | d |
| Processing into Phosphoric Acid and Triple Superphosphate | e | d | e | d |
| Total | 14.53 | d | 14.76 | d |

TABLE I-6 (Continued)

Page 2 of 2

[a] Expressed as 1980 dollars/ton annual capacity "bone dry;" rock assumed to contain 2 percent moisture after rock drying.

[b] No difference among alternatives.

[c] Includes $1.97/ton "bone dry" port handling and $5.15/ton "bone dry" barge transport.

[d] Costs dependent on customers and existing equipment; cannot be determined.

[e] Base case; no estimate provided.

## TABLE I-7

## ENERGY USE FOR ALTERNATIVE NO. 2 - NO ROCK DRYER

Page 1 of 2

| Activity | Calculation | Energy Use (Bbl No. 6 Fuel Oil[a]/ton "bone dry" rock)<br>Pascagoula[b] Delivery | Energy Use (Bbl No. 6 Fuel Oil[a]/ton "bone dry" rock)<br>Other Customer[c] Delivery |
|---|---|---|---|
| Mining | No difference among alternatives | --- | --- |
| Beneficiation | No difference among alternatives | --- | --- |
| Wet Rock Storage | No difference among alternative | --- | --- |
| Wet Rock Loading | $(1.05 \times 10^6$ kwh/yr $\times$ 1466 bbl[d]/$10^6$ kwh) ÷ $3 \times 10^6$ tons/yr | 0.0005 | 0.0005 |
| Rail Transport | (700 Btu[e]/ton-mile × 60 miles) ÷ (151,000 Btu/gal × 42 gal/bbl) ÷ 0.87[f] | 0.0076 | 0.0076 |
| Barge Transport | (600 Btu[g]/ton-mile × 440 miles) ÷ (151,000 Btu/gal × 42 gal/bbl) ÷ 0.87[f] | 0.0478 | 0.0478[h] |
| Rock Unloading and Storage (Dry and Wet Systems) | $(4.57 \times 10^6$ kwh/yr $\times$ 1466 bbl/$10^6$ kwh) ÷ $1 \times 10^6$ tons/yr | 0.0067 | 0.0067[i] |
| Rock Grinding | (1) Dry. $(3.07 \times 10^6$ kwh/yr $\times$ 1466 bbl/$10^6$ kwh) ÷ $1 \times 10^6$ tons/yr | 0.0045 | 0.0045[i] |
| | (2) Wet: $(18.4 \times 10^6$ kwh/yr $\times$ 1466 bbl/$10^6$ kwh) ÷ $1 \times 10^6$ tons/yr | 0.0270 | 0.0270[i] |
| Processing Into Phosphoric Acid and Triple Superphosphate | (1) Electricity: $(7.25 \times 10^6$ kwh/yr $\times$ 1466 bbl/$10^6$ kwh) ÷ $1 \times 10^6$ tons/yr | .0106 | j |
| | (2) Fuel Oil: 180,100 bbl/yr ÷ $1 \times 10^6$ tons/yr | .1801 | j |
| | Subtotal | 0.1907 | j |
| Total | | 0.2848 | j |

---

[a] Energy use is expressed in terms of No. 6 fuel oil for comparison purposes. No. 6 fuel oil has an energy content of 151,000 Btu/gal.

[b] Assumed to be 1,000,000 tons/year "bone dry" or 1,149,000 tons/year "wet" (13 percent moisture).

[c] Assumed to be 2,000,000 tons/year "bone dry" or 2,299,000 tons/year "wet" (13 percent moisture).

TABLE I-7 (Continued)

Page 2 of 2

[d] Assumes 36.7 percent energy conversion efficiency for electric power generating facilities.

[e] An average based on the following references: Congressional Research Service, 1977; Bevilacqua, 1978; Mays and others, 1976; Goodson, 1976; Eldridge and Van Gorp, 1980; and Charles River Associates, Incorporated, 1980.

[f] Conversion from tons "wet" to tons "bone dry."

[g] An average based on the following references: Congressional Research Service, 1977; Bevilacqua, 1978; Goodson, 1976; Eldridge and Van Gorp, 1980; and Charles River Associates, Incorporated, 1980.

[h] Based on distance to mouth of Mississippi River which is approximately 440 miles.

[i] Assumed same as at Pascagoula plant.

[j] Dependent on customers and equipment; cannot be determined.

## TABLE I-8

## ECONOMIC COSTS OF ALTERNATIVE NO. 2 - NO ROCK DRYER

Page 1 of 2

| Activity | Capital Costs[a] |  | Annual Operating Costs[a] |  |
|---|---|---|---|---|
|  | Pascagoula Delivery | Other Customer Delivery | Pascagoula Delivery | Other Customer Delivery |
| Mining[b] | -- | -- | -- | -- |
| Beneficiation[b] | -- | -- | -- | -- |
| Wet Rock Storage[b] | -- | -- | -- | -- |
| Wet Rock Loading at Mine | 1.13 | 1.13 | 0.23 | 0.23 |
| Rail Transport | 0.00 | 0.00 | 2.57 | 2.57 |
| Barge Transport and Port Handling[c] | 0.00 | 0.00 | 7.12 | 7.12 |
| Rock Unloading and Storage | 9.00 | d | 0.85 | d |
| Rock Grinding (wet) | 5.10 | d | 1.17 | d |
| Processing into Phosphoric Acid and Triple Superphosphate | 10.70 | d | 6.04 | d |
| Total | 25.93 | d | 17.98 | d |

TABLE I-8 (Continued)

[a] Expressed as 1980 dollars/ton annual capacity "bone dry;" "wet" rock assumed to contain 13 percent moisture.

[b] No difference among alternatives.

[c] Includes $1.97/ton "bone dry" port handling and $5.15/ton "bone dry" barge transport.

[d] Costs dependent on customers and existing equipment; cannot be determined.

## TABLE I-9

## COMPARISON OF MCC ROCK DRYING ALTERNATIVES[a]

Page 1 of 2

| Impact Issues[b] | Proposed Action - Rock Dryer at Mine | Alternative No. 1 - Dry Rock on Delivery | Alternative No. 2 - Process Wet Rock[d] |
|---|---|---|---|
| Energy Use (bbl/yr) | 176,000 | 189,000 | 285,000 |
| Capital Investment[c] ($10^6$ dollars) | 4.00 | 14.53 | 25.93 |
| Annual Operating Cost[c] ($10^6$ dollars/yr) | 12.85 | 14.76 | 17.98 |
| Air Quality | Significant $SO_2$ and PM emissions at Ona; meets all standards. | Significant $SO_2$ emissions at Pascagoula; may require special mitigation for PSD permit approval. | Significant $SO_2$ emissions at Pascagoula; may require special mitigation for PSD permit approval. |
| Land Use (acres) | 10 | 12 | 12 |
| Water Quality | No adverse effect. | Temporary effects from dredging in Bayou Casotte. | Temporary effects from dredging in Bayou Casotte. |
| Other Considerations | No adverse effects. | Some uncertainty introduced by need for dredge and fill permit. | Some uncertainty introduced by need for dredge and fill permit. |
| Feasibility/Reliability | No concerns. | No concerns. | Slight increase in potential for plant shutdown due to wet rock grinder malfunction. |

TABLE I-9 (Continued)

Page 2 of 2

| Impact Issues[b] | Proposed Action - Rock Dryer at Mine | Alternative No. 1 - Dry Rock on Delivery | Alternative No. 2 - Process Wet Rock[d] |
|---|---|---|---|
| Market Potential | Maximum flexibility to satisfy customer demands. | Very limited market for wet rock at present. No flexibility to meet changing customer demands. | Very limited market for wet rock at present. No flexibility to meet changing customer demands. |

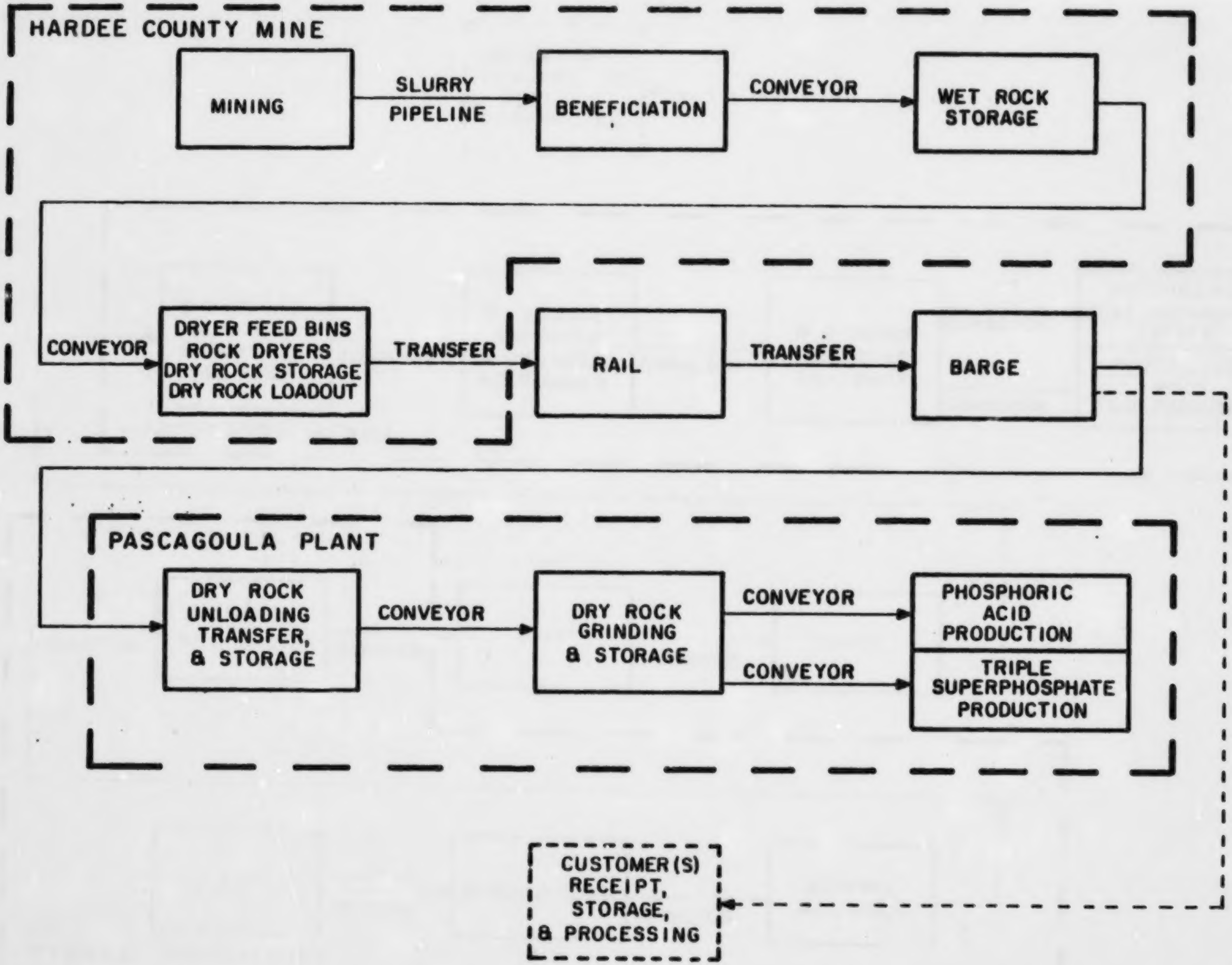
---

[a] Comparisons are made for processing of rock at the Pascagoula plant.

[b] All impacts are expressed per ton of "bone dry" rock.

[c] Costs are given only for facilities needed to provide 1,000,000 tons "bone dry" rock/year to MCC's Pascagoula plant; no costs are reported for rock shipped to other customers.

[d] Assumes existing NPDES permit is not revised to allow greater effluent discharge to Bayou Casotte. For the effects of allowing increased liquid waste discharge, see Section 5.3.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MINING
SLURRY PIPELINE
BENEFICIATION
CONVEYOR
WET ROCK STORAGE
CONVEYOR
DRYER FEED BINS
ROCK DRYERS
DRY ROCK STORAGE
DRY ROCK LOADOUT
TRANSFER
RAIL
TRANSFER
BARGE
PASCAGOULA PLANT
DRY ROCK UNLOADING TRANSFER, & STORAGE
CONVEYOR
DRY ROCK GRINDING & STORAGE
CONVEYOR
CONVEYOR
PHOSPHORIC ACID PRODUCTION
TRIPLE SUPERPHOSPHATE PRODUCTION
CUSTOMER(S) RECEIPT, STORAGE, & PROCESSING

Figure I-1. Proposed Action - Rock Dryer at Mine.

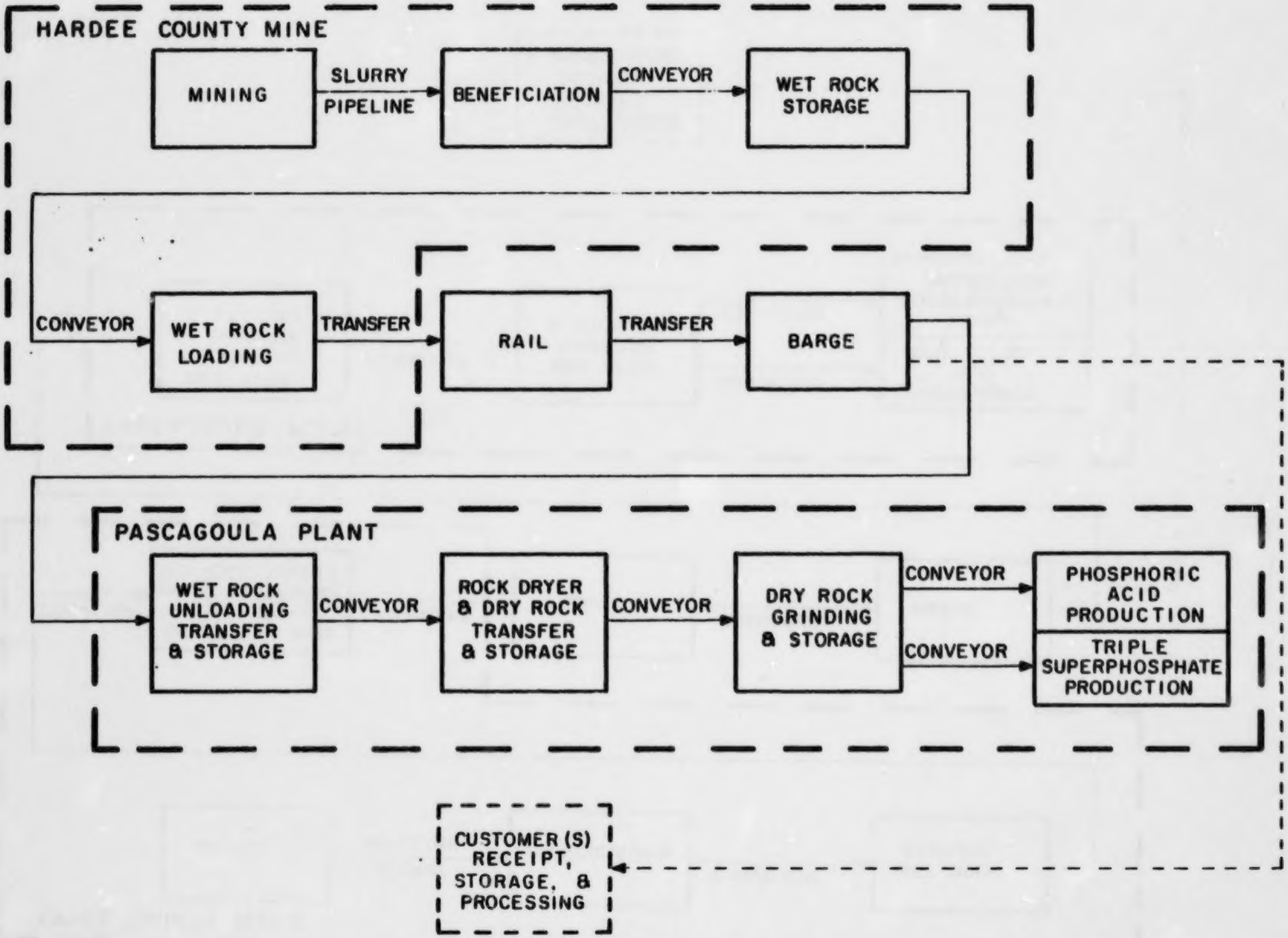

HARDEE COUNTY MINE
MINING
SLURRY PIPELINE
BENEFICIATION
CONVEYOR
WET ROCK STORAGE
CONVEYOR
WET ROCK LOADING
TRANSFER
RAIL
TRANSFER
BARGE
PASCAGOULA PLANT
WET ROCK UNLOADING TRANSFER & STORAGE
CONVEYOR
ROCK DRYER & DRY ROCK TRANSFER & STORAGE
CONVEYOR
DRY ROCK GRINDING & STORAGE
CONVEYOR
CONVEYOR
PHOSPHORIC ACID PRODUCTION
TRIPLE SUPERPHOSPHATE PRODUCTION
CUSTOMER (S) RECEIPT, STORAGE, & PROCESSING

Figure I-2. Alternate No. 1 - Rock Dryer at Chemical Plant.

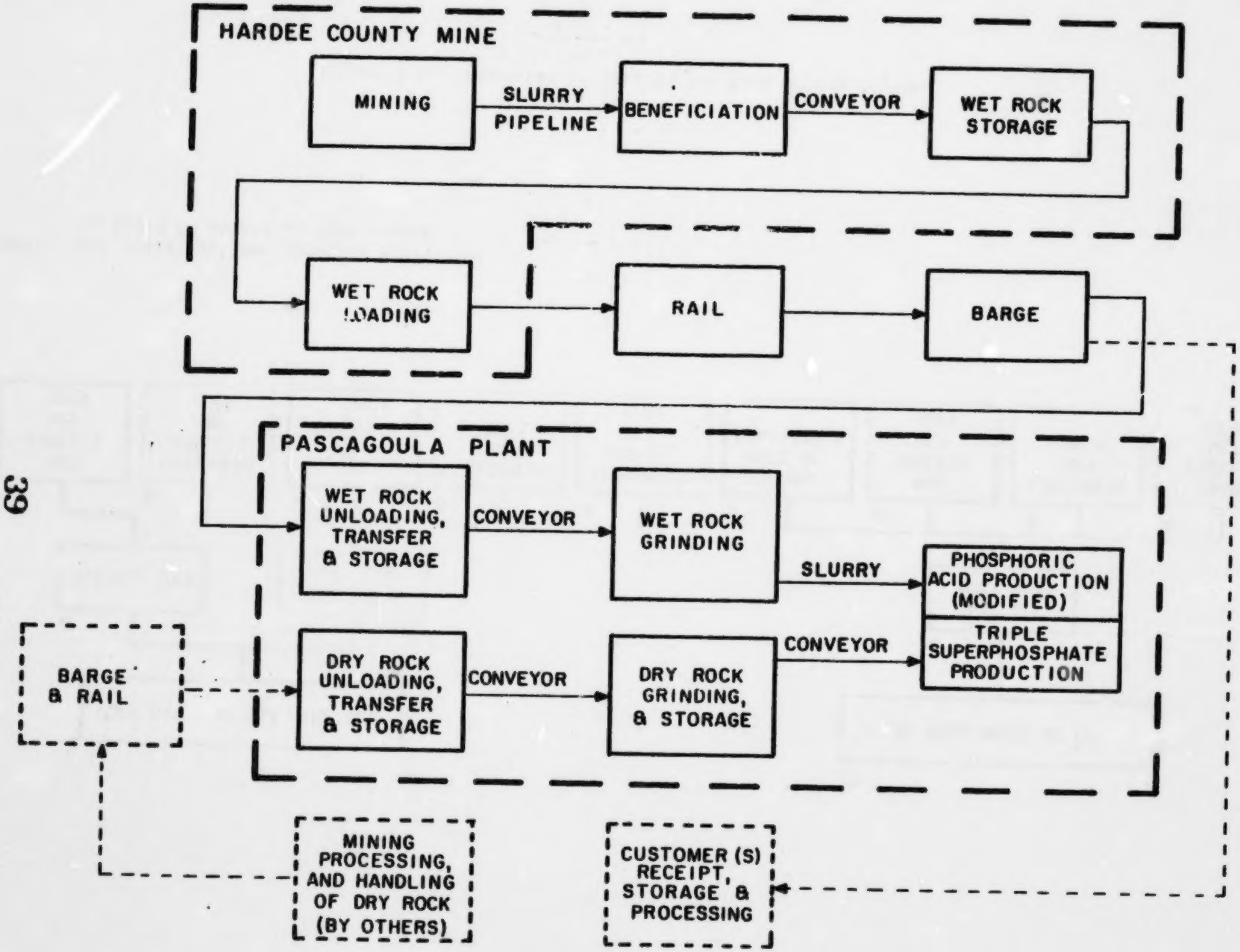
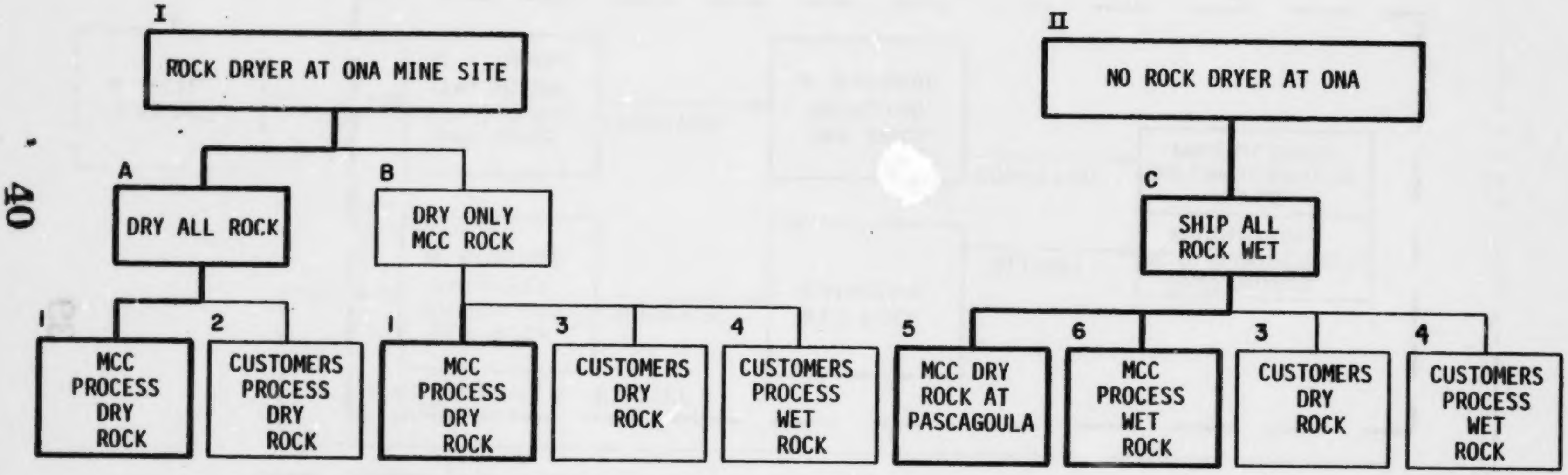

HARDEE COUNTY MINE
MINING
SLURRY PIPELINE
BENEFICIATION
CONVEYOR
WET ROCK STORAGE
WET ROCK LOADING
RAIL
BARGE
PASCAGOULA PLANT
WET ROCK UNLOADING, TRANSFER & STORAGE
CONVEYOR
WET ROCK GRINDING
SLURRY
PHOSPHORIC ACID PRODUCTION (MODIFIED)
TRIPLE SUPERPHOSPHATE PRODUCTION
CONVEYOR
DRY ROCK UNLOADING, TRANSFER & STORAGE
CONVEYOR
DRY ROCK GRINDING, & STORAGE
BARGE & RAIL
MINING PROCESSING, AND HANDLING OF DRY ROCK (BY OTHERS)
CUSTOMER (S) RECEIPT, STORAGE & PROCESSING

Figure I-3. Alternate No. 2 - No Rock Dryer.


I
ROCK DRYER AT ONA MINE SITE
A
DRY ALL ROCK
B
DRY ONLY MCC ROCK
1
MCC PROCESS DRY ROCK
2
CUSTOMERS PROCESS DRY ROCK
1
MCC PROCESS DRY ROCK
3
CUSTOMERS DRY ROCK
4
CUSTOMERS PROCESS WET ROCK
II
NO ROCK DRYER AT ONA
C
SHIP ALL ROCK WET
5
MCC DRY ROCK AT PASCAGOULA
6
MCC PROCESS WET ROCK
3
CUSTOMERS DRY ROCK
4
CUSTOMERS PROCESS WET ROCK

NOTE: All heavy outlines indicate activities analyzed in detail in this report.

Figure I-4. Schematic of Alternative Rock Drying Actions.

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Mays, R.A., M. P. Miller, and G. J. Schott, 1976. Intercity freight full utilization at low package densities--airplanes, express trains, and trucks. Transportation journal, 16(1):52.

Texas Instruments, Inc., 1978. Central Florida phosphate industry areawide impact assessment program.

# TECHNICAL SUPPORT DOCUMENT II

## BIOLOGY

# II.0 BIOLOGY

## 1.0 INTRODUCTION

This document provides an overview of the ecosystems that could be affected by the proposed Mississippi Chemical Corporation (MCC) phosphate mine, which will be located in Hardee County, Florida, as shown on Figure II-1. This report emphasizes the major biological subsystems on the site as well as important impacts of the mining activity on these communities. The data sources for the baseline assessments included the Application for Development Approval for a Development of Regional Impact (ADA/DRI) which was prepared for the site (MCC, 1977); environmental studies on adjacent properties (Farmland Industries, Inc, 1979; CF Mining Corporation, 1976); black and white aerial photographs; a wetlands survey by $CH_2M$ Hill, Inc (1979); and site specific field surveys conducted during wet and dry seasons of 1980.

A general description of the proposed project is provided in Chapter 2.0 of the Environmental Impact Statement and in the ADA/DRI (MCC, 1977) which were prepared for this project. The MCC site consists of 14,850 acres of land. A total of 8,914 acres on the site are considered by MCC to contain mineable phosphate reserves, and most of this area will also eventually be used for clay storage.

Ecological features of significance on the MCC property include 2,980 acres of forested and non-forested wetlands and two fresh water streams, Brushy and Oak Creeks. Both of these streams have a mean annual flow which is greater than 5 cfs on some parts of the MCC property.

The proposed project comprises both spatial and temporal characteristics that may affect the biota in the project area. Spatially, those biological systems likely to be affected by the project include communities on or near the areas which will be mined, used for plant construction, or used for clay storage. In addition, some habitats outside of the property boundaries, particularly downstream ecosystems, are also likely to be affected during some phases of the mining activities. In addition to the spatial distribution of impacts, there is a

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Bevilacqua, Oreste M., 1978. Energy conservation and intercity freight transport. In: Transportation planning and technology, 4: 227-240.

Charles River Associates, Incorporated, 1980. Energy requirements for metals production: comparison between ocean nodules and land-based resources (draft final report). Prepared for: National Oceanic and Atmospheric Administration. CRA #492, Boston, Mass.

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The primary biological impacts which will result from implementation of the proposed project in the study area can be classified as: construction effects (such as noise, dust, and mechanical disturbances); effects of mining and clay storage (displacement of habitat); and water removal and effluent discharge impacts (modification of wetlands hydrology, sediment release).

# 2.0 PRIMARY CONCERNS - GENERAL CONSIDERATIONS

## 2.1 WETLANDS

Approximately 490 acres of hardwood swamps and 2,490 acres of marshes occur within the proposed project area. These wetlands are considered to be the most ecologically important systems on the site that are subject to modification by the planned mining activities. Wetland areas are of special concern because they:

- Enhance the quality of water that flows through them,
- Have high niche hypervolume, associated with vegetational diversity, and a concomitantly high animal diversity,
- Provide flood control and water retention capacities during periods of high water,
- Provide habitats for some species considered to be of special importance.

In addition to a discussion of wetlands structure on the site, an evaluation of ecological importance is also presented, based primarily on wetlands interaction with 5 cfs streams, location in floodplains, and/or vegetational characteristics.

## 2.2 STREAMS OVER 5 CFS, MEAN ANNUAL FLOW

Two lotic (flowing water) bodies on the MCC site have mean annual flows that exceed 5 cfs: Brushy Creek, with a flow exceeding 5 cfs along its full length on the property; and Oak Creek, which exceeds 5 cfs along the lower two-thirds of its length on the MCC site (Figure II-2). Portions of each of these streams are scheduled to be mined by MCC. The evaluation of mining impacts on these streams includes a discussion of their importance to fish and wildlife, based on existing conditions, their susceptibility to mining activities, and their potential for restoration following proposed mining operations.

## 2.3 SPECIES OF SPECIAL CONCERN

The diversity of terrestrial and fresh water habitats on the MCC property provides the requirements for several species which have protected status or are important for recreational purposes. The habitat requirements, location (if observed on the site), and susceptibility to mining activities of each of these species are described in Section 3.4.

## 3.0 EXISTING CONDITIONS

This section describes the biological characteristics of terrestrial, wetland, and aquatic habitats on the MCC property. These descriptions are based primarily on field surveys but also include verification of existing data, where appropriate.

The biological systems which exist on the site have been greatly influenced by the recent history of the area. Much of the MCC site was timbered in the early 1900's and converted to a cattle operation which has been in continuous operation for over 50 years. The rangeland on the MCC site has been relatively intensively managed, resulting in modifications to the natural systems on the site. Cattle have had free access to most of the site for several decades and nearly every natural system has experienced some degree of impact. Without the impact of phosphate mining, the biological systems on the site would either remain as they presently are or be modified as they are managed in response to recommendations made by the soil convervation service and other agricultural advisors.

### 3.1 TERRESTRIAL

### 3.1.1 Vegetation

Five vegetation types or terrestrial communities have been identified in the MCC study area along with two types of wetland systems (Table II-1) (MCC, 1977). There are currently three natural upland communities: the xeric hammock, the mesic hammock, and the rangeland. Some limited pine flatwoods occur on the site in close association with the rangeland and are treated as a part of the rangeland community in this study. Two other habitats on the site are characteristic of societal activities: (1) agricultural, including one citrus grove, and extensive pastureland; and (2) ruderal, comprising fencerows, ditches, and roadsides. These communities are shown on the vegetation map in Figure II-3. Table II-2 provides a comprehensive list of the plant species occurring in each habitat. Threatened or endangered species are discussed in Section 3.4. The total number of plant taxa recorded on the site was 190. Methods used in sampling and surveying the various upland communities are described in the next section, followed by a description and discussion of the major vegetation upland communities on the site.

### 3.1.1.1 Methods

Baseline data were gathered through a literature survey and field studies. The primary published source of information pertaining to the upland vegetation was the ADA/DRI for the site (MCC, 1977). Field studies were conducted in April and August 1980. Sampling of the upland communities was through a qualitative analyses. Black and white aerial photography (scales: 1" = 200' and 1" = 2,000'), topographic maps of the same scales, and the vegetation map contained in the ADA/DRI were useful in determining the aerial extent of the various communities.

### 3.1.1.2 Habitats

#### Xeric Hammock

Xeric hammocks within the project boundary occupy only about 30 acres, which is less than 1 percent of the total area (Figure II-3). Major factors which contribute to the xeric nature of this community include: well-drained soils containing little organic material; high evaporation loss; and large water uptake by tree roots (MCC, 1977). The xeric hammock on the site is the same as that described by Laessle (1942) and corresponds with the sand scrub range community classification of the U.S. Department of Agriculture (1958). It is characterized by a dominance of live oak in the overstory. However, live oak within the xeric hammocks on the project site are rarely larger than 15 inches (38.1 cm) DBH (diameter at breast height). Longleaf pine (Pinus palustris) and sand live oak (Quercus geminata) also occur in the overstory, although to a lesser extent than live oak (Q. virginiana). The tree limbs are richly festooned with Spanish moss and other epiphytes, such as the resurrection fern (Polypodium polypodioides) and a variety of bromeliads. The understory is widely scattered and is composed primarily of turkey oak (Quercus laevis), sand live oak, and live oak. Saw palmetto (Serenoa repens) occurs in patches and covers about 50 percent of the soil surface; otherwise, the sandy ground is only sparsely vegetated. Occasional ground cover species include paspalum (Paspalum spp.), wiregrass (Aristida stricta), and crabgrass (Digitaria adscendens).

The xeric oak hammocks on the site exhibit signs of recent surface burning (e.g., burned bark, scarred trees). This is typical of communities such as these where fire plays an important role in the maintenance of a subclimax seral stage. Fires are either started by lightning or, more often, by cattlemen and other land managers (USEPA, 1979). The dry undergrowth helps spread the fire through the community. Since scrub oak and longleaf pine are capable of surviving occasional surface fires, these species often dominate in communities which are maintained by regular fires. Although live oaks are not particularly fire tolerant (Kurz and Godfrey 1962), their relatively large size appears to protect them from "cool," surface fires. In the absence of fire, the organic ground layer increases, leading to mesic conditions and the subsequent invasion of species characteristic of the mesic hammock (Laessle, 1942).

Although cattle have been allowed free access to onsite xeric hammocks, the sparseness of suitable ground forage limits the amount of grazing the association can sustain. It is probable that the presence of cattle has modified the ground cover to some extent since xerophytic plants are generally not very resilient to grazing or trampling. Forage yields are so low that these sites are usually disregarded when native forage resources are evaluated (MCC, 1977).

## Mesic Hammock

Mesic hammocks occur in areas of intermediate soil moisture. They are richer in organic matter and have a greater water-holding capacity than xeric hammocks and often provide ecotones or buffer zones between the sensitive wetlands and the commonly occurring agricultural uplands. Laessle (1942) has suggested that the mature mesic hammock may be the product of succession from the drier conditions of the xeric hammocks. However, fire can cause the mesic hammock to regress towards the scrub stage of succession.

Mesic hammocks occupy over 770 acres, or 5 percent of the site (Figure II-3). The better drained soils of the mesic hammocks on the site are drier and more leached of soil nutrients, creating environmental constraints similar (though less severe) to the xeric hammock. As a result, better drained mesic hammocks have a greater contingent of live oak in the overstory and more saw palmetto and wiregrass in the ground stratum than do the wetter mesic hammocks. On the site, this community extreme is isolated in extent, occupying the upper periphery of sloping land.

Generally, however, mesic hammocks are associated with drainages and streams, and are therefore present in floodplains on the site. This vegetation type is most extensive along the Brushy Creek floodplain, particularly in Sections 31, 36, and 24. The most significant mesic hammock associated with the Oak Creek drainage is found in Section 29 (Figure II-3). These areas have slightly wetter soils and, where left relatively undisturbed, support a slightly greater floral diversity than the drier mesic hammocks. However, much of the mesic hammock habitat located in the floodplain has been partially cleared and seeded to improved pasture grasses. These areas are classified as mesic hammock wherever overstory vegetation still predominates (MCC, 1977).

The mesic hammocks on the site are characterized by a dominant overstory of live oak. Laurel oak (Quercus hemisphaerica) and slash pine (Pinus elliottii) also occur as overstory sub-dominants. Understory dominants include wax myrtle (Myrica cerifera), live oak, water oak (Quercus nigra), myrtle-leaved holly (Ilex myrtifolia), tallowwood (Ximenia americana), muscadine grape (Vitis rotundifolia), and peppervine (Ampelopsis arborea). Sabal palm is also a component of the understory, but to a lesser extent. The ground cover is usually sparse, possibly as a result of grazing activities and the general lack of abundant sunlight in areas with dense canopy closure. The ground stratum is usually dominated by Bahia grass (Paspalum notatum), saw palmetto, or wiregrass. Other plants include American beautyberry (Callicarpa americana), creeping charlie (Lippia nodiflora), tickseed (Coreopsis leavenworthii), and zephyr lily (Zephranthes treatiae).

Although much of the mesic hammock community on the site has been disturbed or partially altered by man, many large, old live oaks (greater than 4 feet [122 cm] DBH) are still present on the site. Areas partially surrounded by hydric communities (marshes or swamps) appear to have relatively well-developed strata with greater numbers of species. The higher diversity may be due to the greater protection from fire disturbance afforded by the wetlands, as well as greater isolation from cattle grazing. Hence, in some areas, such as in Section 29 where marshes, swamps, and mesic habitat are closely interrelated geographically, biotic and abiotic interactions may be so interdependent as to warrant treatment of these areas as ecosystems rather than independent communities.

## Palmetto Rangeland/Pine Flatwoods

Palmetto ranges are a modified form of pine flatwoods. This habitat is the most common vegetative type in Florida (Monk, 1968) and the dominant vegetative association on the MCC site. Pine flatwoods resemble palmetto ranges floristically except for the prevalence of a pine canopy predominated by longleaf pine in higher areas and slash pine in less drained locations, and a corresponding reduction in saw palmetto undergrowth. Palmetto rangeland, along with the occasional pine flatwoods, comprise approximately 6,002 acres or 40 percent of the total site.

Rangeland is not structurally diverse. The dominant species throughout the rangeland is saw palmetto. Other understory vegetation includes such species as wax myrtle, sand live oak, and young pine. The densest understory occurs where the rangeland meets marshes or drainages. Here the understory becomes mostly mesic, supporting dense growths of wax myrtle. These brushy areas between rangeland and marshes are ecotonal habitats supporting species common to the periphery of the marshes and the rangeland.

During the dry winter and spring seasons, annual vegetation in these habitats dies back, and the ground cover becomes more susceptible to fire. Typically, flammable material builds up over a period of 2 to 5 years until consumed by fire. The resulting ground fire characteristically spreads rapidly through the broad, flat area. Aside from aiding in the recycling of nutrients tied up in dead plant tissues, the relatively frequent fires also limit the establishment of tree species to those which can establish and grow quickly or are otherwise resistant to fire. Pine trees are more resistant to fire than hardwoods and, as a result, they usually dominate the overstory (MCC, 1977). However, pines have generally been extensively timbered throughout much of the area, and much of the natural or planted regrowth is harvested prior to full maturity to provide fencepost material. This practice leaves large, relatively treeless tracts that serve as rangeland. As a result, over 60 percent of the association has a canopy coverage of less than 20 percent (as compared to the 50 to

75 percent canopy coverage in untimbered pine flatwoods throughout Florida) (MCC, 1977).

Palmetto clumps are common in the rangeland on the project site, but a variety of low shrubs, grasses, and herbs sometimes dominates the ground flora. The principal species include Bahia grass, wiregrass, gallberry (Ilex glabra), and bracken fern (Pteridium aquilinum).

## Agricultural Lands/Ruderal Habitats

Agricultural land uses occurring on the property include citrus groves and improved pasture, while ruderal habitats consist of a variety of locally disturbed areas. A single citrus grove occupies 28 acres, or less than 1 percent, of the total property acreage (Section 17, Figure II-3). Improved pasture occupies 5,040 acres, or 32 percent, of the total property acreage. Ruderal acreage totals approximately 62 acres of this pastureland, or less than 1 percent of the site (MCC, 1977).

Important pasture grasses are Bermuda grass (Cynodon dactylon), Bahia grass, and crabgrass. Wherever improved pastures are left undisturbed, early successional species such as smutgrass (Sporobolus poiretii), ragweed (Ambrosia artemisiifolia), dog fennel (Eupatorium capillifolium, and E. compositifolium), and blackberry (Rubus spp.) begin to invade. If succession is allowed to continue, within 5 years, a community very similar to the palmetto range will be established. If the area is protected from fire, vegetation will eventually succeed into a mesic hammock.

Locally disturbed ruderal areas such as roadsides, ditches, and fencerows contain a variety of weedy plants. Species diversity can be relatively high in these areas, particularly for herbaceous species. These ruderal areas include species such as those found in the agricultural lands as well as species adapted to growing in wet ditches, such as soft rush (Juncus effusus) or pennywort (Hydrocotyle umbellata).

### 3.1.2 Animals

The wildlife value of a particular habitat is determined primarily by the vegetation characteristic of that community, although the faunal composition may vary with local land use practices. The MCC property displays a diversity of variable intensity land use areas interspersed with relatively undisturbed native vegetation. This creates high habitat diversity, increases the number of ecotonal areas near the border of contrasting land use units, and increases the number of habitats available to vertebrate species.

Most of the upland areas on the MCC property currently support some form of agricultural activity, or have been affected by past disturbances such as logging. Trees and understory vegetation have been thinned throughout most of the area to enhance the growth of ground forage plants. This alteration of habitat characteristics on the site results in decreased vertebrate population density and diversity. Small,.less cover-dependent, and more mobile vertebrate species which can effectively utilize the expanded ground cover have been favored by these modifications (Table II-3).

#### 3.1.2.1 Methods

Studies to document the composition and relative abundance of the vertebrate fauna inhabiting the proposed mine site included a literature survey and field efforts: the field efforts were conducted during April and October 1980. A review of the literature indicates that 301 vertebrate species (37 mammal, 189 bird, 51 reptile, and 24 amphibian) have ranges and habitat requirements which include various portions of the MCC property (Hall and Kelson, 1959; Burt and Grossenheider, 1976, Conant, 1958: Robbins and others, 1966).

During each field effort, 59 census points (Figure II-4) were used in an avian auto survey. These census locations were distributed throughout the site and included areas representative of each of the major habitats. Observations were made at each station for a maximum of 15 minutes or until no new bird species were seen. Additionally, observations of scats, tracks, and other signs were made to determine the occurrence of mammals, reptiles, and amphibians at each station. The observations for mammals, amphibians, and reptiles were supplemented with a series of habitat searches and nighttime spot lighting. However, the avian fauna of the site is far richer and more diverse than the other vertebrate populations, so emphasis was placed on the composition of the bird community.

During site field investigations, 128 vertebrate species were identified on site, 72 of which were observed only in upland areas. Table II-3 provides a listing of all species which potentially or did occur, their estimated abundance, and habitat requirements. The table also identifies the species observed during the field studies. Threatened or endangered species are addressed in Section 3.4.

### 3.1.2.2 Faunal Communities Associated with Upland Habitats

#### Xeric Hammock

The environmental extremes associated with the xeric hammocks limit the density and diversity of the species which this habitat can support. Wildlife must be adapted to high temperatures and drought-like conditions to effectively utilize these xeric hammocks. Numerous species feed on the abundant acorn crop in these communities, but relatively few species are considered residents. Typical vertebrate species associated with xeric hammocks include armadillo (Dasypus novemcinctus), gopher tortoise (Gopherus polyphemus), southern fence lizard (Sceloporus undulatus), and ground skink (Lygosoma laterale). Many bird species nest in the xeric hammocks and feed in the nearby communities, and blue jays (Cyanocitta cristata), mocking birds (Mimus polyglottus), mourning doves (Zenaida macroura), and several species of woodpeckers feed extensively within the xeric hammock itself. Gopher tortoise burrows are common in the xeric hammocks on the MCC site. These burrows are commonly used by the tortoises and a variety of commensal species.

## Mesic Hammock

The natural variability of this community type has been increased on the MCC property through the activity of man, primarily through management for cattle and timber production. In better drained areas, these communities are similar to xeric hammocks, while in wetter areas, they can approach the habitat characteristics of a hardwood swamp. Mesic hammocks on the MCC site generally contain numerous large live oak trees and a well-developed understory.

Well-drained mesic hammocks support a greater assortment of food plants than xeric hammocks so that the former habitat type has a better developed vertebrate fauna. Typically, these areas are inhabited by a variety of small mammals, skunks, snakes, and toads. The threatened gopher tortoise and eastern indigo snake (*Drymarchon corais couperi*) are often relatively abundant in these areas.

Mesic hammocks which are not well drained generally contain a variety of grasses and leafy shrubs, supporting rabbits, feral hogs, various tree frogs (*Hyla* spp.), chorus frogs (*Pseudacris* spp.), and raccoons (*Procyon lotor*) in addition to the species occurring in the drier mesic hammocks.

Usage of this community type by ground-feeding birds is also dependent upon local habitat characteristics. In seeded pastures, species such as the eastern meadowlark (*Sturnella magna*) and loggerhead shrike (*Lanius ludovicianus*) predominate, while tall grass and brushy undergrowth is more favorable to bobwhite quail (*Colinus virginianus*), mourning doves, and sparrows. Tree-dwelling birds are more prevalent in mesic hammocks than other upland communities, with bluejays, cardinals (*Cardinalis cardinalis*), mockingbirds, eastern bluebirds

(Sialia sialis), flycatchers, and woodpeckers being the most commonly observed species. Various herons and cranes are locally common along canal and creek banks. As a whole, mesic hammocks can support a large assortment of upland wildlife species due to the broad range of moisture conditions and management practices to which the habitat is subjected.

### Palmetto Rangeland/Pine Flatwoods

Palmetto rangeland is characterized by an abundant ground cover consisting of patches of saw palmetto interspersed with low grasses and shrubs. There is relatively little development of the overstory, although in some areas, pines are present. This results in almost two distinct vertebrate communities associated with this habitat type.

Although the relatively dense palmetto understory provides abundant cover and nesting sites, it is low in forage value. Ground-oriented species associated with this habitat are often wide ranging and tend to rely on insects as a food source. Such species include the armadillo, southern fence lizard, and Florida box turtle (Terrapene carolina). Prairie species are characteristic of the avian community and include Florida bobwhite quail, rufous-sided towhee (Pipilo erythrophthalmus), and eastern meadowlark.

In areas where numerous pines are present, a second stratum is added to the vertebrate community. The pines provide feeding and nesting areas used by gray squirrels (Sciurus carolinensis), Sherman's fox squirrels (Sciurus niger shermani), chickadees (Parus carolinensis), tufted titmice (Parus bicolor), and a variety of insect-eating birds, particularly woodpeckers.

In many ways, the faunal composition of palmetto rangeland can be compared to the more natural pine flatwoods community type, particularly when pines are present. However, because of management of this habitat on the MCC site by man, the palmetto rangeland is lower in faunal diversity than would be expected for a typical pine flatwoods.

### Agricultural Lands/Ruderal Habitats

Improved pastureland is common throughout the site. The reduced habitat diversity provided by this land use practice favors a limited number of wildlife species. Although the wildlife diversity is generally reduced when an upland area is converted to pastureland, the density of each species which can use this habitat is often high.

Wildlife species are confined primarily to such herbivores and granivores as the eastern cottontail rabbit (*Sylvilagus floridanus*), eastern harvest mouse (*Reithrodontomys humilis*), and ground doves (*Columbigallina passerina*), or to insectivores such as armadillos, cattle egrets (*Bubulcus ibis*). eastern meadowlarks, and loggerhead shrikes. Numerous wildlife species use the open areas created by pastures as feeding grounds, moving to adjacent areas to rest. These species include hawks, whitetail deer (*Odocoileus virginiana*), feral pigs (*Sus scrofa*), and eastern diamondback rattlesnakes (*Crotalus adamanteus*).

## 3.2 WETLANDS

### 3.2.1 Vegetation

Wetlands constitute the interface between the terrestrial and aquatic communities. These habitats are the most valuable ecological resource on the site because they serve as valuable habitat for upland biota, and they also enhance local and downstream water quality. Swamps and marshes filter sediments that would otherwise wash into the streams by sheet erosion (USEPA, 1979); they also act as natural flood-controlling features, retarding major flood and runoff water, catching the water that overflows the stream channels and holding it for slower release, later. They catch and absorb water during the wet seasons (summer and early fall in the project area) and subsequently feed this water back into the streams through springs, seeps, and the ground water table. The highest wetland productivity occurs while water is being filtered through the wetlands, i.e., during periods that the wetland is performing the functions of flood control and water quality enhancement.

There are presently 2,980 acres of wetlands on the MCC property, or 20 percent of the total site area (Figure II-3). Hardwood swamps make up 490 acres of the total wetlands and fresh water marshes represent 2,490 acres of the site wetlands. A wetlands map showing hardwood swamp and fresh water marsh locations is shown in Figure II-5.

All of the swamps and most of the marshes on the site are level with, or below, the ground water table during the wet season. During the dry season, ground water levels drop approximately 5 feet or more, making the surface soil only marginally wet in many wetlands. Therefore, many wetland areas become dry during the winter and early spring months. The ADA/DRI submitted for the MCC property (MCC, 1977) discusses in detail the effects of seasonal water fluctuations on local wetland attributes. During the 1980 sampling efforts, the normally wet season was characterized by unusually low rainfall (Figure II-6).

#### 3.2.1.1 Methods

Because of the importance of wetlands in this study, a large part of the field effort was concentrated in assessment of onsite swamps and marshes. The primary literature sources were the ADA for the site (MCC, 1977) and the wetland evaluation by $CH_2M$ Hill (1979). Wetlands were surveyed with the aid of black and white aerial photography (scales: 1" = 200' and 1" = 2,000'). Because small connecting channels between wetland areas could not always be identified from the topographic maps and aerial photographs, field verification of their existence was often necessary to assess wetland-stream contiguity.

Field studies were conducted during April and August 1980. Sampling of wetlands vegetation was conducted quantitatively in the overstory using the point-centered quarter (PCQ) method for trees and large shrubs (Cottam and Curtis, 1956). The Braun-Blanquet method (1932), as modified by Wikum and Shanholtzer (1978), was used to semi quantify herbaceous and low woody vegetation. Qualitative surveys were also conducted to include any species omitted during the quantitative sampling.

#### 3.2.1.2 Habitats

##### Hardwood Swamps

Hardwood swamps on the site correspond to the swamp range designation of the U.S. Department of Agriculture (1958). Hardwood swamps comprise 490 acres, or about 3 percent, of the project area (Figure II-5). These swamps vary from small, isolated stands of 3 acres to a 64-acre swamp located in Section 17. Although generally classified as hardwood swamps, several are either mixed hardwood swamps, dominated by deciduous trees, or bayheads, also called bay swamps (Monk, 1966). A bayhead is a forested wetland dominated by one or more species of evergreen bay trees and occurring in peat-forming depressions (Wharton and others, 1977). The best example of a bayhead swamp is located in Section 28 West (Figure II-3). Although localized areas may be dominated by evergreens, most of the swamps on the site are best characterized as the mixed hardwood variety.

Most of the pre-existing floodplain swamps have either been logged and planted to pasture or have succeeded to more mesic species due to channelization, diversion of stream channels, and draining of adjacent wet areas. The only significant swamps directly interacting (connected) with streams and their floodplains on the site are in Section 29, where backwater flooding from Oak Creek into the swamp occurs, and in Section 17 where the swamp drains to the south to form a branch of the Oak Creek headwaters. Overstory composition of the swamps on the site is variable, depending on the degree of soil inundation as well as the degree of previous logging activity. Generally, the wettest portions of the swamps are dominated by blackgum (*Nyssa sylvatica* var. *biflora*), with red maple (*Acer rubrum*), swamp ash (*Fraxinus pauciflora*), and sweetbay (*Magnolia virginiana*) occurring as subdominants. The slightly drier edges of the swamp are characterized predominantly by slash pine. pond pine (*Pinus serotina*), sweetgum (*Liquidambar styraciflua*), and American elm (*Ulmus americana*). However, these species are often intermixed throughout the swamps due to local differences in soil moisture and a wide range of water tolerance by some species, such as red maple.

Various point-centered quarter (PCQ) parameters, such as importance values, were determined for individual transects during the 1980 field surveys and are given in Tables II-4 through II-8. Table II-9 gives average importance values for trees in hardwood swamps throughout the site. Red maple, sweetbay, and blackgum have the highest overall importance values for the swamp habitats (Table II-9). Red maple and sweetbay are capable of occupying both the overstory and understory strata because of their tolerance to shade and their ability for rapid growth. Blackgum, or swamp tupelo, is the most water-tolerant species of the three with the highest importance values. Hence, a rise in the water table would favor formation of a blackgum-dominated swamp, and a lowering of the water table would lead to conditions favoring bayhead formation or domination by red maple. Current drainage practices and past logging may favor succession toward the bayhead vegetation type.

The understory vegetation of the site's swamps comprises sweetbay, wax myrtle, red maple, blackgum, buttonbush (Cephalanthus occidentalis), sweetgum, sweet-spires (Itea virginica), swamp ash, and possumhaw viburnum (Viburnum nudum). Shrubby growth (wax myrtle and buttonbush) is least abundant in the central portions of the swamps where inundation is most common. The presence of many young sweetbay and red maple trees in the overstory suggests that these communities are perhaps succeeding towards a bayhead vegetation type.

The forest floor is characterized by depressions interspersed with raised hummocks formed from roots and vegetative debris. The more mesic herbaceous species occupy the drier hammocks, and muck/peat soils support hydrophytic emergent species within the hollows. Completely inundated areas support emergent and free-floating hydrophytes. The herbaceous vegetation varies in density and composition in accordance with the amount of standing water and soil saturation. For example, the swamp in Section 16 (Figure II-3) is often flooded with 3 to 4 feet of standing water; here, duckweed (Lemna minor), water-meal (Wolffia sp.), floating heart (Nymphoides aquatica), and frog's-bit (Limnobium spongia) are common. However, in the bayhead in Section 28, where flooding is less frequent, the herbaceous layer consists primarily of a dense growth of ferns (primarily Osmunda cinnamomea, Thelypteris normalis, and Woodwardia virginica). Herbaceous species commonly encountered in swamps on the MCC site include lizard's tail (Saururus cernuus), spoon-flower (Peltandra virginica), royal fern (Osmunda regalis), and jack-in-thepulpit (Arisaema triphyllum). Virginia creeper (Parthenocissus quinquefolia), poison ivy (Rhus radicans), and smilax (Smilax sp.) are the most common vines throughout the swamp.

The swamps in Sections 17, 22, and 29 (Figure II-3) support a greater herbaceous diversity than any other area on the site, partly because of the greater size of these wetlands and also because they provide a variety of moisture regimes throughout the system. In addition, the overstory canopy in Sections 17, 22, and 29 has been periodically or permanently opened in the hardwood swamps (clearings are 50 to 100 feet wide), producing a highly productive marshlike herbaceous stratum. This modification has provided additional habitat diversity, high edge drama, and an increase in overall wildlife value for the swamp system.

Forage production on the site is limited to the peripheral zones where canopy closure is less complete. Where the canopy is about 40 percent, forage yields average 1,500 to 2,000 pounds of air-dry herbage per acre. Stumps found in the interior of some swamps on the MCC property indicate past lumbering (MCC, 1977).

## Marshes

Marshes occupy 2,490 acres or 17 percent of the MCC property (Figure II-5). The marshes on the site vary from isolated, shallow, temporary ponds to semi-permanent water bodies closely contiguous with the native streams. Although the size and hydrologic regime of the marshes on the site vary significantly, similarities in vegetative associations and zonation are exhibited with respect to water depth. Four zonal communities (Table II-10) have been observed in the marsh vegetation type. These zonal communities are described individually in the following paragraphs and are then summarized to characterize the entire community.

The peripheral marsh zone remains saturated to moist through much of the year but is seldom flooded. In this zone, species common to mesic hammocks and marshes are intermixed. Perhaps best described as a wet prairie (MCC, 1977), this zone is dominated by shrubby vegetation and live oak. Where overstory and understory vegetation are less dense, water pennywort, coinwort (Centella asiatica), blue flag (Iris hexagona), and sedges are most common.

The second zone occurs in areas where the soil is saturated or submerged to a depth of about 10 cm. Diversity is commonly reduced in this zone due to the total dominance of sand cordgrass (Spartina bakerii) or soft rush. Water paspalum (Paspalum dissectum), marsh purslane (Ludwigia palustris), arrowhead (Sagittaria lancifolia), and false pimpernel (Lindernia grandiflora) occur as subdominants in this zone. Some organic deposition occurs here since this zone is slightly more protected from fire than the peripheral zone.

The third marsh zone occurs in areas characterized by 10 to 30 cm of standing water. Clumps of sand cordgrass are the most evident constituent. However, species from the second and fourth zones are also common. Here, fires are infrequent and the substrate is rich in organic deposits.

The fourth marsh zone occurs in submerged areas characterized by about 30 to over 60 cm of standing water. This is the deepest portion of the marsh, and it is most commonly dominated by an association of maidencane (Panicum hemitomon) and pickerelweed (Pontederia cordata), although arrowroot (Thalia geniculata) is also common in this area. Arrowroot grows in tall monotypic stands, thus preventing the intermingling of adjacent pickerelweed and maidencane. Clumps of sand cordgrass and soft rush occur in this zone but are much more abundant in areas characterized by shallower water. Floating plants can be very abundant, even to the point of shading out submerged species. Water hyacinth (Eichhornia crassipes) is frequently abundant in areas previously disturbed, near channelized streams, or cattle crossings. Other more desirable species of floating vegetation which are found in this zone are duckweed, floating hearts (Nymphoides aquatica), and bogmat (Wolffiella floridana), the latter being an extremely valuable fish and wildlife food source. A third stratum may also be identified in this zone; it consists of a very dense growth of submerged aquatic plants, particularly bladderworts (Utricularia purpurea) and spike rush (Eleocharis acicularis).

The percent cover and frequency of marsh species for a semi-isolated marsh in Section 5 are given in Table II-11. As in many of the marshes on the site, pickerelweed and maidencane are the most dominant components of this semi-isolated marsh habitat. Although not encountered in the transects surveyed in this marsh, soft rush and arrowroot are also common in many of the marshes. Sawgrass (Cladium jamaicense) and beakrush (Rhynchospora corniculata) are also present, but occur only occasionally.

Most of the marshes on the site which exhibit the zonation patterns described above are well-established and relatively stable wetland communities. However, marshes which are rarely swept by fire and which are subject to periodic flushing slowly accumulate organic debris which fills the marsh depressions. Without fluctuating water tables, floods, and fires which burn woody shrubs, these marshes would probably succeed toward dominance by woody species and eventually to bayhead communities or perhaps even to hardwood hammocks. Although a few shrubs do occur in local shallow areas within the marshes, only a few of these habitats are dominated by shrubs or small trees, primarily willow and buttonbush. An example of a shrub-dominated marsh occurs on the east side of Section 16 (Figure II-3).

### 3.2.2 Animals

The lowland areas on the site are less suitable for agricultural uses than are the upland areas and, therefore, have not been as severely impacted. These predominantly wetland areas provide considerable food, cover, and nesting places for a variety of wildlife species. Since many vertebrates have evolved behavioral or physiological adaptations which make them dependent upon a particular wetland type, wetlands fauna are often very sensitive to changes in community characteristics.

Faunal diversity and density in swamps and marshes may increase during periods of higher water levels (MCC, 1977). In addition, swamps provide shade, cool temperatures, and nutrients which affect species composition and productivity in the streams (USEPA, 1979). Marshes as well as swamps provide water during dry seasons to animals largely confined to upland habitats. Marshes are particularly used by wading birds.

#### 3.2.2.1 Methods

Surveys of vetebrates in wetlands habitats were conducted during the same seasons following the same methods as the census of upland habitats described in Section 3.1.2.1. During these field investigations, 125 vertebrate species were identified on site, 46 of which were observed only in upland areas. Table II-3 lists all species which potentially occur, their estimated abundance, and habitat requirments. Threatened or endangered species are discussed in Section 3.4.

#### 3.2.2.2 Faunal Communities Associated with Wetland Habitats

#### Hardwood Swamps

Hardwood swamps have a high vegetative diversity and alternating wet and dry habitats; these characteristics provide a greater habitat diversity than any other community type on the site. Hardwood swamps surpass all other systems on the site, except the largest permanent marshes, in their importance as wildlife refuges during periods of stress and for their importance as nutrient sinks.

Hardwood swamps are composed of several distinct strata. Amphibians and reptiles dominate the lower strata, relying heavily on insects for their food requirements. Amphibians in these habitats are represented by tree frogs (*Hyla* spp.), southern leopard frogs (*Rana pipiens*), pig frogs (*Rana grylio*), and dwarf salamanders (*Manculus quardridigitatus*). These species in turn are preyed on by carnivores such as the eastern mud snake (*Farancia abacura*), Florida water snake (*Natrix sipedon*), and the cottonmouth water moccasin (*Agkistrodon piscivorus*).

The large deciduous trees which provide the canopy of the swamp are used as nesting and feeding habitats by a variety of birds, particularly during yearly migrations. Prominent among those birds which extensively use the habitat provided by swamp trees are flycatchers, wrens, thrushes, vireos (*Vireo* spp.), and wood warblers. In addition. hardwood swamps are the preferred habitat of wood ducks (*Aix sponsa*), and the well-developed canopy provides roosting habitat for owls, hawks, and some wading birds.

Swamps are often bounded by relatively dry edges which are densely vegetated. These edges provide habitat for raccoons, skunks, rabbits, other small mammals, and whitetail deer. Several of the swamps on the property are bordered by extensive fresh water marshes. The combination of habitats created by these two adjacent systems results in an extremely diverse vertebrate fauna. These two communities are usually connected hydrologically and often function as integrated systems, making them by far the most important wildlife habitats on the site.

## Marshes

There are several hundred fresh water marshes on the MCC property, varying widely in size and vegetative composition. Most of these marshes lose their standing water during parts of the dry season. Wildlife usage of these marshes is highly dependent on marsh size and vegetative composition as well as on the season of the year.

Many of the small, shallow marshes on the site are typified by wet prairie vegetation and do not provide the abundance of food and hiding places of larger areas. Additionally, these small marshes are more prone to prolonged drying which retards the growth of aquatic vegetation. Therefore, wildlife usage of many of the small, seasonal marshes is sporadic. At times, these areas are extensively used for feeding and nesting by a variety of shorebirds such as the greater and lesser yellowlegs (*Tringa melanoleucus* and *T. favipesi*, respectively), common gallinule (*Gallinula chloropus*), and white ibis (*Eudocimus albus*). Rice rats (*Oryzomys palustris*) and cottontail rabbits are also commonly found. These small marshes are also important breeding areas for a variety of frogs and toads and serve as feeding and nesting habitat for the Florida sandhill crane (*Grus canadensis pratensis*) and other wading birds.

Larger marshes or those attached to permanent water bodies provide a more stable environment, and wildlife usage does not vary as significantly with the seasons as in the smaller marshes. These larger, more continuously wet marshes develop denser, more diverse vegetation than smaller marshes and thus provide habitat for a wider range of vertebrate species. Common grackles (*Quiscalus quiscula*), red-winged blackbirds (*Agelaius phoeniceus*), song sparrows (*Melospiza melodia*), swamp sparrows (*M. georgiana*), and a variety of wading birds are common in these larger marshes. The permanent water provides breeding grounds for many amphibians which are in turn used as a food source for carnivores, such as alligators (Alligator mississippiensis), anhingas (Anhinga anhinga), and raccoons.

Generally, fresh marshes have high ecological value and sensitivity because of their extensive use as wildlife breeding habitats and their support of threatened or endangered species. Because they can support a diversified contingent of endemic species, large marshes exceed most other onsite communities in ecological value. This value is recognized by the Florida Committee on Rare and Endangered Plants and Animals in their designation of interior freshwater marshes as "regions of special concern." Large, permanent marshes are also important to wildlife as refuges during fires or times of drought and serve as biological reservoirs from which species can recolonize adjoining lands after disturbance.

### 3.2.3 Important Wetland Systems Onsite

Certain areas of the MCC property appear to combine the environmental values of the swamp, marsh, and mesic hammock to form systems that are far more productive than might be expected by the isolated habitats. These areas are shown in Figure II-7, and their qualities and sizes are given in Table II-12. These ecosystems are recognized as being integrated wetland systems, although the presence of mesic hammock in several areas gives them certain upland qualities not usually associated with wetlands.

The mesic hammock, discussed in Section 3.1.1.2 under terrestrial communities, represents the most valuable upland onsite and is the most closely associated to wetlands both physically and biologically. Besides adding to the vegetational and habitat diversity of the wetlands it surrounds, the mesic hammock provides a buffer zone from many agricultural disturbances. The large hardwood trees characteristic of mesic hammocks produce significant amounts of forage for many vertebrate species. Whitetail deer, gray squirrels, and feral pigs all depend heavily upon the mast produced by these trees. Sherman's fox squirrel, although not truly characteristic of mesic hammocks, does successfully utilize these habitats on the MCC site.

The swamps and marshes provide water and additional food for animals living in the mesic hammocks and contribute to maintenance of mesic conditions (by protection from fire and occasional flooding). Another attribute of these habitat systems is the increase in ecotonal types that occurs, which enhances wildlife diversity due to concentration of animal species in areas where benefits can be derived from two or more plant communities.

Thus, mesic hammocks, when combined with adjacent marshes and swamps, form wetland systems that provide an important diversity of habitats so that many of the niche requirements of various faunal species may be met within a relatively confined area.

The extent, timing, frequency, and duration of the contiguity between a wetland and its associated hydrology, significantly influence its contribution to regional water quality. As excess water moves out over a floodplain, the velocity is reduced and suspended particles are deposited (Snedaker and Lugo, undated). Thus, wetlands which are more contiguous with systems that experience occasional flooding have a much greater capacity for water quality enhancement than isolated wetlands. A wetland which is highly contiguous also has greater potential to act in detention of flood waters, whereas an isolated wetland functions mainly as a retention site ($CH_2M$ Hill, Inc., 1979). Further, wetlands which are most often subject to seasonal flooding from streams receive nutrient subsidies during periods of inundation and, thus, are highly productive.

The swamps and marshes comprising the contiguous wetland systems on the site are all naturally contiguous to Brushy or Oak Creeks either as headwaters (Systems B and C, Figure II-7) or as parts of the 25-year floodplain (Systems A, D, and E, Figure II-7). The degrees of contiguity considered in this study are illustrated in Figure II-8. Wetland systems such as Systems A, D, and E (Figure II-7) which are naturally contiguous and within the 25-year floodplain contribute significantly to the water quality of the streams. Systems B and C, although valuable as headwater wetlands, are probably less important contributors to overall stream quality since they are "connected" rather than "contiguous" to mainstream flow. Because of their relatively high contiguity, the wetlands in Systems A through E are superior to other, more isolated or perched wetlands on the site in terms of their capacity for water retention and flood control and maintenance of water quality in some creeks.

Although it is difficult to quantify the overall ecological value of swamps versus marshes of equivalent size and edge, swamps with their higher structural and floral diversity are more difficult to reproduce artifically. Hence, a swamp which is intermittently connected to the mainstem stream is considered more ecologically valuable than a marsh with the same degree of contiguity. Though difficult to accomplish, the essential wetland functions of flood control, water quality enhancement, and habitat characteristics can probably be restored in fresh water marshes. Such restoration is much less certain for swamps, however, as re-creation of prototype swamp habitats is currently in an early phase, and is not well documented.

### 3.2.4 Existing Man-Induced Impacts on Site Wetlands

Throughout most of the property, ditching of the marshes for drainage purposes has occurred. Although many of these marshes still retain some water throughout most of the year, drainage of the marshes results in a reduction of the hydroperiod and accelerates succession towards shrubby growth. However, drainage also results in some positive effects, including an increased contiguity to regional drainage systems of otherwise isolated wetlands. In addition, macrophytes commonly line these ditches, creating some wildlife habitat within the pasture areas.

The most significant impact on the regional drainage system occurs as a result of dredging and channelization along much of the length of Brushy and Oak Creeks on the MCC site. This results in increased conductivity and flow rates, decreased flood duration, decreased flooding over land adjacent to the stream and changes in water quality. Where wetlands still occur in the Brushy Creek basin, they are mostly isolated (except for ditch connections), with extensive pasture or mesic habitat separating them from the stream channel. Intermittent spoil piles created by dredging. partially inhibit natural interaction with the adjacent floodplain wetlands. These spoil piles also introduce weed species, particularly dog fennel; channelization also alters normal macrophyte composition in the stream channel. Solid stands of water hyacinth now populate much of Oak Creek and parts of Brushy Creek adjacent to and south of Highway 64.

Another factor which contributes to a loss in diversity of site habitats is cattle grazing, particularly along peripheries of swamps and marshes adjacent to pastureland. Shallow areas crossed regularly by cattle are often devoid of any ground vegetation or are dominated by water hyacinths in deeper water.

Although past lumbering operations have removed swamp trees and probably resulted in some changes in species composition, these wetland communities affected by man presently appear to have retained most of the characteristic wetland functions.

## 3.3 AQUATIC

### 3.3.1 Introduction

The MCC site is drained by six small dark water streams; they all flow in a general north to south direction, eventually emptying into the Peace River. Although two of these streams do not traverse the property they do receive runoff and drainage from the property. In addition to the natural stream courses and their tributaries, much of the property is also crossed by man-made channels. Natural streams in Hardee County are classified as dark water, swamp, and bog streams (MCC. 1977). The waters in these streams are tinted dark brown by the presence of organic acids leached from decaying organic matter in the adjacent watershed.

The physical characteristics of water bodies on the site are also affected by seasonal fluctuations in rainfall. Flow in these streams is usually very sluggish, except during periods following heavy rainfall. The periods of heaviest precipitation occur during the months of May through September (Figure II-6). During this wet season, numerous areas of standing water occur throughout the property, and large volumes of water move along the channels and creeks. The dry season changes these habitats markedly; many of the water bodies are dry for several months during dry periods, and most streams become intermittent.

Brushy and the southern portion of Oak Creeks are the only streams, or lotic ecosystems, on the MCC property which have mean annual flows greater than 5 cfs. These two streams are considered to be the most important aquatic habitats on the site. More information on physical and chemical characteristics of these streams is provided in the ADA/DRI (MCC, 1977). In addition, a description of each stream's drainage characteristics is provided in this section, followed by a discussion of the methodology used and the results obtained from the aquatic biological survey conducted on the site in April and August 1980.

### 3.3.1.1 Brushy Creek

Brushy Creek enters the MCC property two miles to the north of State Road 64 and exits one mile to the south. It drains a total area of 27 square miles north of State Road 64. Within the MCC property boundaries, it receives drainage directly from 6,959 acres and indirectly (by way of Lettis Creek) from 198 acres.

Brushy Creek has undergone varying degrees of dredging and channelization. Where it enters the property (Station B-1, Figure II-9), a small, shallow channel has been excavated through the surrounding marsh. For the first mile after it enters the property, Brushy Creek maintains a generally straight course and is lined with spoil banks. It then becomes more meandering, although it still appears to have been channelized, with steep banks typical along most of its length. Where it underflows State Road 64 (Station B-2, Figure II-9), Brushy Creek is considerably larger and deeper, and continues in a winding configuration. Backwater marshes are ill-defined and poorly developed in this area. Where the creek leaves the property (Station B-3, Figure II-9), the channel is larger, and the water tends to be almost stagnant. This area appears to have been artifically deepened at some time in the past, but the channel has not been straightened. The adjacent floodplain and marsh areas are extensive and are heavily grazed.

Several jeep trails and cattle crossings intersect Brushy Creek in the site area. Movement of vehicles and animals across the stream has resulted in some stress on the stream bottoms and shorelines in these areas.

### 3.3 1.2 Oak Creek

The present headwaters of Oak Creek originally drained into Brushy Creek rather than directly to the Peace River. A recently constructed channel now diverts all but flood waters into Oak Creek.

At State Road 663, Oak Creek presently drains a total area of 10.6 square miles. Most of the headwaters of this stream are on the proposed mine site where Oak Creek drains 5,738 acres. This creek has been dredged and channelized from the marsh immediately north of State Road 64 to the point where it exits the MCC property at State Road 663. The stream assumes a more natural configuration below State Road 663.

Immediately downstream of the point where Oak Creek underflows the Fort Green-Ona Road, the stream passes through a narrow, shallow ditch (Station O-1, Figure II-9). Flow has been only infrequently noted here, usually after heavy or prolonged rainfall. Where Oak Creek underflows State Road 64 (Station O-2, Figure II-9), the channel has a high cross-section to discharge ratio, resulting in very sluggish flow. Immediately before Oak Creek exits the site (Station O-3, Figure II-9), the stream is wide and sluggish. Oak Creek assumes a shallow geometry after it exits the property at State Road 663.

### 3.3.2 Sampling Stations and Methodology

A sampling program was conducted from April 8 to April 12 1980 for all aquatic biology parameters, with a subsequent sampling effort undertaken in August 1980 for fish. These sampling programs were designed to update and verify previous aquatic studies on the site (MCC. 1977). Biological parameters investigated during the surveys were phytoplankton, aquatic macrophytes, zooplankton, benthic macroinvertebrates, and fish. Physical data collected with each set of biological samples were temperature, pH, dissolved oxygen, transparency, and specific conductance.

### 3.3.2.1 Sampling Stations

Six sampling stations were established (Figure II-9) to provide an assessment of characteristic aquatic habitats in Brushy and Oak Creeks.

Station B-1 was near the point where Brushy Creek enters the north end of the MCC site. The main channel at this point is only about 1 meter wide, but the banks are low and sloping, allowing the creek to flood into adjacent areas during much of the year. There is very little canopy at this location, and the shorelines and stream bottoms are heavily vegetated with macrophytes and filamentous algae.

Station B-2 was at the intersection of Brushy Creek with Highway 64 and Brushy Creek. The creek has been highly modified at this intersection, resulting in a wide, deep pool that is fished frequently by local residents. Sampling was conducted at this locale in the dredged area as well as a few hundred meters upstream and downstream. Most of this section of Brushy Creek is 2 to 3 meters wide and 1 to 2 meters deep. However. considerable variation occurs in the stream bottom topography, with deep pools and shallow areas occuring throughout the length of the creek. The canopy layer is more complete than in upstream areas, except near Highway 64, with relatively few areas of dense macrophyte growth. The stream banks are steeply cut. and most are vegetated with a variety of grasses.

Station B-3 was near the point where Brushy Creek exits the south end of the property. The stream is very wide and sluggish in this area, with extensively wooded banks and a relatively dense growth of water lettuce and water hyacinth.

Station O-1 was near the intersection of Oak Creek and Vandolah-Ona Road. This portion of the creek is often dry or very shallow, with very thick canopy cover along the low banks. No submerged vegetation was noted in this section of the creek.

Station O-2 was at the intersection of Oak Creek and Highway 64. This section of the stream has been dredged in the past, resulting in a large area of nearly stagnant water that is frequently fished by local residents. The areas upstream and downstream of Highway 64 have relatively shallow banks and regularly flood into wetlands, although most of the downstream areas have been channnelized and straightened to reduce the frequency of flooding. There is relatively little canopy along this section of the creek, and most of the surface is covered by water hyacinth.

Station O-3 was near the point where Oak Creek leaves the southeast corner of the property near State Road 663. This section of the creek is very wide, and flows range from slow to nearly stagnant. The banks are lined with scattered willows, pines, and oaks but have very little canopy cover. The water surface is almost completely occluded by water hyacinths.

### 3.3.2.2 Methodology

#### Phytoplankton

Phytoplankton were collected by pumping 10 liters of water, from the surface to near the bottom of the water column, into a container and then collecting replicate, one liter aliquots from this container. The samples were preserved with 40 ml of formalin and were then returned to the laboratory. After the phytoplankton samples were concentrated by settling, the supernatant was removed. Specimens were identified to the lowest practicable taxon and enumerated by the inverted microscope method with a plankton chamber (U. S. Geological Survey, 1977). References which were particularly useful for phytoplankton identification included: Patrick and Reimer (1975), Prescott (1954), Smith (1933) and Whitford and Schumacher (1973). The Shannon-Weiner (Pielou, 1966) index was used to calculate species diversity.

#### Aquatic Macrophytes

The presence of aquatic macrophytes was noted during both field sampling efforts. Specimens were identified in the field in accordance with such references as Godfrey and Wooten (1979), Fassett (1972), Hotchkiss (undated), and Tarver and others (1978).

## Zooplankton

Zooplankton samples were collected by pumping 100 liters of water through a Number 20 (75µm mesh) plankton net. The concentrated sample was then transferred to a plastic bottle, and sufficient formalin was added to make a 10 percent solution. Specimen identification to lowest practicable taxon and enumeration were conducted by using a Sedgwick-Rafter counting chamber at magnifications of 40X and 100X. The references used to aid in specimen identification were: Ahlstrom (1940 and 1943), Edmondson (1959), Ruttner-Kolisko (1974), and Torke (1976). The Shannon-Weiner index (Pielou, 1966) was used to calculate species diversity.

## Benthic Macroinvertebrates

Benthic organisms were sampled both quantitatively and qualitatively during the field surveys on the MCC site. Duplicate quantitative samples were collected near each stream bank and in the center of the stream with a Ponar dredge. Qualitative sampling was accomplished through the use of seines, drift nets, and dip netting. All samples were transferred to plastic bottles with sufficient formalin to make a 10 percent solution. In the laboratory, rose bengal stain was added to facilitate the removal of organisms from the detritus, and "picked" specimens were then placed in 70 percent ethanol with glycerin. Enumeration and identification to lowest practicable taxon was conducted using techniques and magnification appropriate to the organisms collected. References used for the identification of benthic organisms included: Mason (1973), Merritt and Cummins (1978), and Pennak (1978).

### Fish

Fish sampling was conducted at the stations shown on Figure II-9. Collecting gear included a 6 ft x 125 ft bag seine, with a net mesh of 1/2-inch and a bag mesh of 1/8-inch; a beach seine, 6 ft x 40 ft, with 3/8-inch mesh; and a 150-foot experimental gill net consisting of 10 panels, each panel being 15 ft long, and mesh sizes varying from 1/2-inch to 4 inches.

Collections were made by blocking the downstream end of the stream segment being sampled with a beach seine and then seining the width of the stream with a bag seine. The gill net was placed at Stations B-2, B-3, O-2, and O-3 for one 24-hour period each.

The fish that were collected were either identified in the field or preserved by adding formalin to make a 10 percent solution. Preserved specimens were identified in the laboratory by using appropriate taxonomic keys (Douglas, 1974; Eddy, 1977; Smith-Vaniz, 1968; and Stevenson, 1976).

## 3.3.3 Aquatic Communities

### 3.3.3.1 Phytoplankton

Phytoplankton consist of small, photoautotrophic algae that move more or less passively with the water currents. Their occurrence in streams is often a result of cells breaking loose from algal communities attached to a substrate or entering the stream from the out fall of a lake, although slow moving water bodies may support an actively growing algal community (Wetzel, 1975).

During April 1980, phytoplankton were collected from three stations each in Brushy and Oak Creeks (Figure II-9). Phytoplankton densities were high at all of the stations sampled, averaging 527,667 organisms/liter for the Brushy Creek stations and 804,000 organisms/liter at the Oak Creek stations. Although Stations O-1 and O-2 showed lower densities than any of the stations on Brushy Creek, an algal "bloom" at Station 0-3 (2,035,000 organisms/liter) caused the average phytoplankton density at the Oak Creek stations to exceed that at the Brushy Creek sampling locations. Factors which may have contributed to the bloom at Station 0-3 include the slower current, which allows the algae to reproduce in the area. and high nutrient concentrations from decomposing macrophytes.

Green algae (Chlorophyta) and diatoms (Bacillariophyceae) were the most abundantly represented groups (Table II-13). In addition to these major groups, euglenoids (Euglenophyta) were also found at all of the stations sampled; blue-green algae (Cyanophyta) were collected from all of the stations except Station 0-2; and pyrrophytes (Pyrrophyta) were found in low numbers at two of the stations on Oak Creek.

Diatoms were the dominant algae on Brushy Creek at Stations B-1 and B-3, comprising about 83 percent and 70 percent of the community at these respective sampling locations. A species of _Navicula_, a benthic alga, was the most common diatom at Station B-1; it was also relatively abundant, along with _Cyclotella_ sp. at Station B-3. Diatoms and green algae were codominant at Station B-2, each accounting for about 42 percent of the total community collected. The same species of _Navicula_ which dominated the diatom populations at Stations B-1 and B-3 was also the most common diatom at Station B-2; _Oedogonium_ sp. was the most prevalent species of green algae collected, accounting for almost 60 percent of the Chlorophyta found at this station.

On Oak Creek green algae were the most abundant group at Stations 0-1 and 0-3, where they made up almost 50 percent of the phytoplankton population. At Station 0-1, several species, including _Chlorella_ sp., _Scenedesmus_ sp., an unidentified chlorophyte, and _Palmodictyon_ sp. were all relatively common representatives of the green algal community. Members of the Chlorococcales groups and _Volvox_ sp. were the most abundant component of the Chlorophyta at Station 0-3. Although chlorophytes (especially Chlorella sp., Scenedesmus sp., and an unidentified green alga) were a numerically important segment of the phytoplankton community at Station O-2, the diatoms were more abundant (Table II-13). Dominance was well distributed among the diatoms at Station O-2, with two species of Navicula, two species of the benthic alga Synedra, a species of Nitzschia (also benthic), and a species of Melosira (a true planktonic form) being among the most common forms collected.

Species diversity ($\overline{d}$) was very similar among all of the stations sampled. Diversities ranged from a low of 3.43 at Station B-1 to 4.00 at Station B-3.

### 3.3.3.2 Aquatic Macrophytes

In this study, the term "macrophyte" is used to define the vascular hydrophytes and the larger attached algae which are part of the periphyton. Macrophytes perform several important functions in aquatic ecosystems. They are primary producers in that they contribute to the supply of oxygen in the water by withdrawing carbon dioxide during photosynthesis and producing oxygen. Macrophytes are also important contributors of organic matter to the detrital food chain. They provide habitat, cover, and food for many species of animals including amphipods, crayfish, and larvae of aquatic invertebrates and are also of considerable importance to fish, birds, and mammals.

The four major "forms" of macrophytes which were found in this study are classified as:

1. Emergent - These macrophytes are rooted to the soil and are close to or below the water level for much of the year, but their leaves and reproductive organs are aerial.
2. Floating-leaved - These macrophytes are rooted in submerged soils, with many of their leaves floating or completely aerial.

3. Free-floating - These plants are not normally attached but are often entangled in other plants. They may be either completely submerged, at the surface, or emergent from the surface.

4. Submergent - These are attached to submerged materials or surfaces by roots, rhizoids, or by the whole thallus. Their leaves and reproductive organs remain submerged throughout much of the year.

Aquatic macrophytes found at sampling stations along Brushy and Oak Creeks are identified in Table II-14 along with their forms and location with respect to the stream channel. The distribution of macrophytes in Brushy and Oak Creeks appears to be restricted primarily to areas where the overhead canopy is minimal or absent. The limiting effect of shading is particuarly evident at Brushy Creek, where stretches of the stream which are lined by live oak, slash pine, or willow lack any significant macrophytic growth. Conversely, open areas of Oak Creek south of State Road 64 frequently support macrophytic growth. Other factors which are limiting to macrophytic growth in the site streams include the steeply cut banks and the soft, unstable substrate in the stream channels. The steep banks, produced largely as a result of channelization, greatly diminish the potential for development of littoral zone or shoreline vegetation. Additionally, the instability of the stream bottom in Brushy and Oak Creeks makes portions of these streams unsuitable for the establishment of most vegetative species.

Where fresh water marshes are contiguous to streams, macrophytic vegetation common to the marsh community is abundant along the edges of the stream. The littoral zone usually comprises emergent vegetation, whereas the macrophytes in the stream channel are either submerged where flow is moderate, or free-floating where water is slow-moving and deep. However, the species that are present in the channel are also usually associated with the littoral community. This is primarily because plants that occur in moderate to fast-flowing water have: (1) tough, flexible stems, and (2) a creeping growth habit, either by stolons or rhizomes, with frequent adventitious roots, which enable them to maintain their position (Hynes, 1972). These adaptations are, for example, characteristic of parrots-feather (Myriophyllum aquaticum) which occurs occasionally in monotypic stands in moderately fast water of Brushy Creek.

Water hyacinth (Eichhornia crassipes) occurs in great abundance throughout Oak Creek, south of State Road 64, where the current velocity is very slow, and occasionally in Brushy Creek where the current is slow, or fence wire crossings prevent flushing of floating vegetation. The high density of water hyacinth is due to the water hyacinth's ability to "exploit" the disturbed environment of the channelized stream by prolific vegetative reproduction while crowding-out competition from other species.

Although the comment by Haslam (1978) that "river plants are sensitive indicators of the conditions in which they live" may merit debate, pure stands of water hyacinth which choke the Oak Creek channel definitely indicate a poor quality stream environment. These stands reduce flow, restrict light penetration into the water column, severely lower dissolved oxygen levels by blocking water/air surface contact. and limit the number and kinds of fish (and other organisms) to those few which can tolerate these conditions. Thus, unlike most other macrophytes which usually have positive effects, water hyacinth can become so abundant that they stress the aquatic environment. Brushy Creek. though channelized throughout most of the site, supports relatively few water hyacinths, primarily because of the significant canopy cover which occurs along most of the stream. The abundance of water hyacinth in Oak Creek makes this stream a less healthy and diverse aquatic habitat than Brushy Creek. Brushy Creek has higher dissolved oxygen levels and more abundant and diverse fish life.

The well-established presence of several exotic species of plants in both Brushy and Oak Creeks suggests that past disturbance of these streams, especially channelization, has permanently altered their "natural" attributes.

### 3.3.3.3 Zooplankton

The zooplankton are small, aquatic animals that are incapable of moving against a current and, therefore, depend primarily upon water flow for their distribution. Most zooplankton are filter feeders, removing particulate matter, such as bacteria, algae, protozoa, and detritus, from the water. The zooplankton are a crucial link in the food web between phytoplankton and most other consumers, such as young fish. The most common zooplankton are rotifers, cladocerans, and copepods.

The biological survey conducted in April 1980 included the collection of zooplankton at three station locations each on Brushy and Oak Creeks. Zooplankton species enumerated from these samples were referrable to either of two crustacean orders, Cladocera and Copepoda, or to the phylum Rotatoria (rotifers). The density and relative abundance of these three major taxa are presented in Table II-15 along with the density and relative abundance of all zooplankton enumerated.

Other taxonomic groups which were commonly observed in the zooplankton samples were the oligochaetes (worms) and Chironomidae (midge flies). Since these two groups are generally considered benthic invertebrates and probably constitute the drift fauna, they are not discussed in this section.

The mean density of the total zooplankton enumerated ranged from a minimum of 4/liter at Station O-1 to a maximum of 36/liter at Station B-1. The maximum observed at the upstream station of Brushy Creek was due to the presence of high numbers of rotifers and copepods. Similarly, high mean densities of the total zooplankton enumerated at Oak Creek Stations O-2 (9/liter) and O-3 (10/liter), were also concurrent with high numbers of rotifers and copepods. These two major taxa comprised an average of approximately 96 percent of the total zooplankton community enumerated for both creeks.

Mean densities for the rotifers ranged from 2/liter at Stations B-3 (23 percent of the total zooplankton) and O-1 (52 percent of the total zooplankton) to 22/liter (61 percent of the total zooplankton) at Station B-1. Euchlanis sp. and an unidentified rotifer, probably a member of the group Bdelloidea, contributed 74 percent to the rotifer community at Station B-1. Although these zooplankters were observed in other samples, their numbers did not account for a major segment of the rotifer community. Other species which commonly occurred in samples from both creeks were: Lecane luna, Lepadella sp., Monostyla bulla, Platyas patulus P. quadricornis, and Polyarthra sp.

The relative mean abundance for the copepods enumerated from Oak and Brushy Creeks represented 56 and 47 percent, respectively, of the total zooplankton community and occasionally accounted for more than 60 percent at individual stations. Although these crustaceans were the primary component of the zooplankton population observed for Oak Creek samples, their densities were never greater than 6/liter. Maximum numbers for the copepods were recorded at Station B-1 (13/liter), representing 35 percent of the zooplankton community at this station.

Typically, the nauplii were the most abundant copepod forms enumerated at each station. Mean densities of this immature stage accounted for 83 percent and 88 percent of the total copepod community at Brushy and Oak Creeks, respectively. The highest mean densities that were recorded for total copepods coincided with the greatest densities recorded for nauplii on each creek, 9/liter at Station B-1 (71 percent of total copepods) and 6/liter at Station O-2 (89 percent of total copepods). Cyclopoid copepodites were also found in all samples and occurred in highest densities at Station B-1 (3/liter).

Although cladocerans were observed in all samples, their numbers never comprised a major segment of the zooplankton community. Total mean densities for Cladocera were typically less than 1/liter. For both creeks, the cladocerans comprised an average of approximately 4 percent of the total zooplankton community. Alona guttata was the only cladoceran species which was identified in all of the samples. The relative mean abundance for this species comprised 46 and 42 percent of the total cladoceran mean density for Brushy and Oak Creeks, respectively.

Diversity values calculated using the Shannon-Weiner Index ($\overline{d}$) ranged from 2.61 for Station O-1 to 3.97 for Station O-2. These values are simlar to those which are considered typical of relatively non-polluted aquatic systems (Wilhm, 1970).

In summary. although their numbers were few, the rotifers and copepods were the most numerous zooplankters recorded from samples collected from Brushy and Oak Creeks during April 1980. Various investigators (Hynes, 1972; Steuer, 1910) have indicated that the zooplanktonic communities of streams are composed primarily of rotifers. These zooplankters are usually regarded as cosmopolitan and occupy a great variety of aquatic and semi-aquatic habitats.

Genera of rotifers which Steuer (1910) regards as lotic plankton and which were collected during the present investigation include: Asplanchna, Brachionus, Keratella, Polyarthra, and Synchaeta. Welch (1963) states, however, that these genera are also commonly represented in lakes and ponds. Further, the plankton of streams is not comprised of plankters adapted exclusively to running waters. These rotifers and other plankters may have been brought into Brushy and Oak Creeks with surface runoff from adjacent lentic communities.

The low densities of zooplankton collected during the current study may be attributed to the fact that, in general, plankton populations in streams are inherently unstable and are very sensitive to variations in physicochemical conditions. Both the 1975-76 (MCC, 1977) study and the present study indicated that wide fluctuations occurred in the volume of water as well as in dissolved oxygen concentrations in streams on the MCC site.

### 3.3.3.4 Benthic Macroinvertebrates

Benthic macroinvertebrates are bottom dwelling organisms which live all or part of their life cycle in or upon various underwater substrates. These organisms are important in aquatic ecosystems because of the diverse trophic levels they occupy. They also represent an important food source for fish and include species of commercial and recreational importance. Since many of these organisms are relatively sessile in lotic ecosystems, their presence or absence may be indicative of an average composite of physical factors over extended periods. Thus, pulses in water quality are less likely to modify the community structure of these benthic animals than are prolonged events. For these reasons, the distribution, density, and diversity of some macroinvertebrates is often considered indicative of the quality of the aquatic ecosystem.

In addition, the presence of other organisms, particularly habitat-forming macrophytes, and snag, or plants, roots, and overhanging branches, dramatically influences distribution and abundance of macroinvertebrates (Benke, 1979). The density, or abundance, of a particular species may also be indicative of the relative fitness of an organism for a particular environment as well as a measure of its success in utilizing community resources.

## Population Density and Composition

Forty-eight genera of benthic invertebrates representing 22 families were identified in Ponar grab samples collected from Brushy and Oak Creeks in April 1980 (Table II-16). The density of the benthic organisms collected ranged from 1614/m$^2$ at Station B-2 to 8137/m$^2$ at Station B-1. The dominant benthic organisms in both creeks were oligochaetes (worms), which comprised an average of approximately 57 percent of the benthos enumerated. The only other major taxonomic groups of benthic organisms having average densities which exceeded 10 percent of the benthos from all sampling locations on either Brushy or Oak Creeks were: Chironomidae (midge flies), 17 percent at Brushy Creek and 15 percent at Oak Creek; and Sphaeriidae (fingernail clams), 29 percent at Oak Creek.

Most of the worms collected in the grab samples from Brushy and Oak Creeks were species of Limnodrilus and immature Tubificidae. Combined densities for these worms ranged from 266/m$^2$ at Station O-3 to 4592/m$^2$ at Station B-1. For the midge flies, species of Polypedilum and Tanytarsus, with average densities of 913/m$^2$ and 516/m$^2$, respectively, comprised 62 percent of the midges enumerated in the grab samples from Brushy Creek. In Oak Creek, Polypedilum (138/m$^2$) and Tanytarsus (481/m$^2$) were also very common and comprised 45 percent of the midges enumerated. An additional midge, Chironomus, was very abundant in Oak Creek, with an average density of 395/m$^2$ which represented 29 percent of the midges enumerated. Chironomus was collected from Brushy Creek in much lower densities (average of 4/m$^2$). Bivalves (clams) from the family Sphaeriidae were collected at all sampling stations but were generally more abundant in Oak Creek than in Brushy Creek, with average densities of 908/m$^2$ and 165/m$^2$, respectively.

The density of benthos in drift samples collected over a 24-hour period at Brushy and Oak Creeks in April was quite low, ranging from 18 to 434 organisms (Table II-17). The low drift densities were probably indicative of the relatively low stream flow and the predominance of non-drifting worms within the areas of the creeks which were sampled. The taxa collected were similar to those enumerated in the Ponar grab samples.

Diversity values, calculated using the Shannon-Weiner Index ($\bar{d}$), ranged from 2.9, for Station B-1, to 3.7 for Station B-3 (Table II-16). These values are similar to those of relatively non-polluted aquatic systems.

Equitability values, calculated using the Lloyd-Ghelardi Index (e), ranged from 0.28 at Station B-1 to 0.65 at Station B-2 (Table II-16). These values are low in relation to values described by Weber (1973) for non-polluted southeastern streams and appear to be indicative of a slight level of degradation.

In comparison with the investigation completed in 1975-1976 (MCC, 1977), the large densities of benthos collected during April 1980 follow the general trend noted in the previous study, with higher densities occurring in late winter and spring. The dominance of worms and midges in the April 1980 collections was also similarly noted during the 1975-1976 investigation. In comparison to the previous study, both worms and midges were generally more abundant in the April 1980 collections than at any period in the past study. For the midges, during both the 1975-1976 study and the April sampling period, the genera Polypedilum, Tanytarsus, and Chironomus were very common. The other group of benthic organisms found in large densities during the April 1980 collection period was the Sphaeriidae. These clams were also very common during the 1975-1976 study. The occurrence of these benthic organisms is apparently indicative of the available substrate types as well as the natural stresses which occur in the creeks as a result of fluctuations in water quantity and quality.

Observations during field sampling in April 1980 indicated that the predominant substrate in Brushy and Oak Creeks was fine sand overlain by varying amounts of silt and detritus. The results of laboratory particle size analyses conducted for sediments from Brushy and Oak Creeks also showed the presence of fine to very fine sand (Figure II-10). Silt and detritus appears to be most extensive in the downstream segments of these creeks, especially at Stations O-2 and O-3 on Oak Creek and Station B-3 on Brushy Creek. However, analyses for volatile solids in sediments of these two streams suggest high organic content in the upstream stations at Brushy and Oak Creeks; the highest overall percentage of volatile solids was at the downstream station of Oak Creek (Table II-18).

Various investigators (Poddubraya and Sorokin, 1961; Oliver, 1971) have indicated that tubificids and much of the remainder of the benthic invertebrate community are typically concentrated within the top 10 cm of the substrate, but that oligochaetes are often found at lower depths (Brinkhurst and Jamieson, 1971; Davis, 1974). The nature of the sediment as well as the quality and quantity of organic matter reaching the sediment are major factors in oligochaete distribution (Brinkhurst and Cook, 1974). Chironomids normally occur over a wide range of substrate types but show larger densities in soft mud-detritus substrates. DeMarch (1976) indicated that Sphaerium sp. is dominant in "sand" substrates.

The results of both the 1975-1976 investigation and the April and August 1980 studies indicate that wide fluctuations occur in the volume of water as well as dissolved oxygen concentrations in Oak and Brushy Creeks. During a relatively low annual rainfall cycle in the 1975-1976 investigation, the discharge for these creeks varied from less than 0.01 cfs to 6.6 cfs while dissolved oxygen ranged from 0.4 mg/liter to 12.2 mg/liter (Environmental Science and Engineering, Inc., 1977).

Although no discharge measurements were recorded in April and August 1980, the recorded dissolved oxygen concentrations ranged from 0 mg/liter to 6.9 mg/liter.

In summary, worms and midge flies were the dominant benthic invertebrates collected from Brushy and Oak Creeks in both the 1975-1976 investigation and the April 1980 collections. The dominance of these benthic organisms is apparently related to the occurrence of suitable substrate types and the tolerance of these organisms to the wide fluctuations in water quality and quantity which occurs in the site creeks.

### 3.3.3.5 Fish

As with most aquatic communities, the fish in the present study are the most visible and important organisms from a recreational and aesthetic point of view. Fish are the main vehicle for transforming energy of the aquatic ecosystem into a form available for human use, e.g., through recreational fishing. In addition, smaller species of fish, although not directly utilized by man, harvest the plankton and benthic organisms of the area and, in turn, become food sources for larger fish that are directly utilized by man.

Twenty-nine species of fish (excluding an unidentified immature sunfish) representing 11 families were collected from the sampling stations on the site (Table II-19). All of the species collected are common in the site area (CF Mining Corporation, 1976 and Texas Instruments, Inc., 1978). The species composition for fish collected during the April 1980 sampling effort is discussed separately in this section for Brushy and Oak Creeks.

#### Brushy Creek

Twenty-six species of fish in addition to an unidentified, immature sunfish were collected from sampling stations on this stream. These species represented 10 native families, including gar (Lepisosteidae), bowfin (Amiidae), minnows (Cyprinidae), sucker

(Catostomidae), catfish (Ictaluridae), topminnows (Cyprinodontidae), livebearers (Poeciliidae), silversides (Atherinidae), sunfish (Centrarchidae), perches (Percidae), and one exotic family, walking catfish (Clariidae).

The mosquitofish (Gambusia affinis) was present at all of the locations sampled on Brushy Creek and was the most abundant species collected, comprising 55 percent of all fish collected. The second most abundant fish collected at all of the sampling locations was the least killifish (Heterandria formosa), which represented about 38 percent of the fish captured from Brushy Creek.

The mosquitofish and the least killifish are very common in virtually all of the inland lakes and streams of Florida (McLane, 1955). Both of these species are tolerant of harsh conditions, such as those created by fluctuating water levels and velocities caused by alternating wet and dry hydroperiods. The mosquitofish is one of the first species to invade new territory when heavy rains and rising water levels increase the aquatic habitat available. The species is tolerant of low dissolved oxygen, high carbon dioxide, and a wide range of pH conditions. It feeds principally on mosquito larvae, but it also takes other aquatic and terrestrial insects when available. It has a high reproductive capacity and produces young during all months of the year except from November through February (McLane, 1955).

The least killifish occupies some of the same habitats as the mosquitofish; however, it is usually restricted to areas of denser vegetation. The species is ubiquitous in most roadside ditches, small streams, and in the lakes of central Florida. The least killifish feeds primarily on insect larvae, small crustaceans, and filamentous algae (McLane, 1955). The reproductive habits of this species correspond closely to that of the mosquitofish.

Forage species, including the shiners, topminnows, brook silverside (Labidesthes sicculus), the bluespotted pygmy sunfish (Enneacanthus gloriosus), and swamp darter (Etheostoma fusiforme) comprised more than 2 percent of all the fish collected from Brushy Creek. These fish are important because they feed on organisms at the lowest trophic level of the food chain and are, in turn, preyed upon by carnivores such as gar and bowfin which are at the top of the food web.

Several species of centrarchids which are of recreational importance were also collected. These include: yellow bullhead, largemouth bass, warmouth, bluegill, redear, and spotted sunfish. This group of fish is well-represented in Florida because most of its species inhabit quiet, well-vegetated waters which are abundant in the state (Layne and others, 1977). Although the bowfin is not generally considered to be a recreationally important species, it is taken by local anglers with hook and line. Recreational fishing from the stream banks is common at Station B-2.

The only exotic species collected, the walking catfish was captured at Station B-3. This species, introduced into Florida from Bangkok in 1966 (McClane, 1978), is now found in certain areas around Tampa Bay and from Lake Okeechobee south to Miami.

The spatial distribution of fishes in Brushy Creek is affected by a number of abiotic factors, including rainfall, runoff, and subsequent stream flow, and water temperature. At the uppermost station (B-1), 15 species of fish were collected. The species were composed primarily of forage fish, including the shiners, topminnows, livebearers, bluespotted sunfish, and a darter. Thus the fish community at this location was composed primarily of the smaller fishes that are tolerant of harsher and more unstable environmental conditions such as wide fluctuations in temperature and stream flow. In addition, the presence of the brook silverside only at Station B-1 on Brushy Creek may be biologically significant in that its presence is considered indicative of clean water (Layne and others, 1977). At Stations B-2 and B-3, 13 and 17 species of fish, respectively, were collected. Included in the species composition were top carnivores such as gar, bowfin, bullhead, and largemouth bass. At these locations, the fish community consists of species that require a more stable environment.

### Oak Creek

Nineteen species of fish were collected from sampling stations on Oak Creek. These species represented eight families including the gars, bowfin, suckers, catfish, topminnows, livebearers, sunfish, and perches.

The two most abundant species captured at all of the collecting stations were the mosquitofish and the least killifish. These two species represented 75 and 16 percent, respectively, of the total catch from Oak Creek. Other numerically important species which were collected included the brown bullhead (Ictalurus nebulosus), which represented 3 percent of the catch; 6 species of centrarchids, including the warmouth (Lepomis gulosus), redear sunfish (L. microlophus), bluegill (L. macrochirus), spotted sunfish (L. punctatus), and the largemouth bass (Micropterus salmoides), comprised approximately 2-1/2 percent of the catch.

Catch results indicate that the fish communities at the three Oak Creek stations are quite different. Station O-1, the uppermost station, produced only three species of fish: the mosquitofish, least killifish, and Seminole killifish (Fundulus seminolis). The low number of species collected may be due to the extreme fluctuations in water level which the upper reaches of this stream experience. Many species can not tolerate such extremes, but flood conditions provide ideal habitat for mosquitofish and least killifish to forage and reproduce.

Farther downstream at collecting Stations O-2 and O-3, there was a larger variety of species than at the upstream station. At these locations, 14 and 11 species, respectively, were collected. In the area of these stations, Oak Creek is not subject to the extreme water level fluctuations found at Station 0-1. As a result, the communities of macroinvertebrates the substrate, and vegetative cover is more stable, providing more suitable habitat for a number of fish species. Several species of recreational value, including the largemouth bass, bluegill, redear sunfish, spotted sunfish, warmouth, and yellow and brown bullheads were collected at Stations 0-2 and 0-3. The bowfin was also present at these collecting stations, and although not normally considered a sport species, this fish is taken by local anglers.

## 3.4 THREATENED OR ENDANGERED SPECIES

The U.S. Department of Interior Fish and Wildlife Service (FWS) and the Florida Committee on Rare and Endangered Plants and Animals (FCREPA) have published lists of species which are of concern due to their decreasing numbers. The species which have been listed by these agencies and have been observed or may occur on the site are discussed in this section.

### 3.4.1 Vegetation

None of the species which are included as endangered or threatened by the FWS (1980) was observed in the MCC study area. Harper's beauty (Harperocallis flava) and Chapman's rhododendron (Rhododendron chapmanii) are the only two species known to occur in Florida, and their current ranges are limited to the panhandle. Hence, the likelihood that either species occurs on the site is extremely low.

The FCREPA has listed 11 species (Pritchard, 1978), which have been discussed in detail in the ADA/DRI (MCC, 1977), including their current status and likelihood of occurrence in the study area. Spoonflower (Peltandra sagittifolia) which the ADA/DRI classified as a rare plant with a moderate chance of occurrence on the site was the only species on the Florida list observed on the site during this study. This population is a component of the swamp community located in Section 28 West (Figure II-3). It is probable that it occurs in other parts of the property as well since this habitat type is common throughout the study area.

### 3.4.2 Animals

Ten federally listed vertebrate species occur or may occur on the site, while 40 vertebrates listed as threatened, endangered, of special concern, or of undetermined population status by the State of Florida may also occur (Table II-20). Throughout the course of the field efforts, particular emphasis was placed on locating species listed by either of these agencies. The presence of 15 state or federally protected species is presently documented for the MCC site (Figure II-11).

### 3.4.2.1 Federally Listed Species

#### Florida Panther - Endangered

Populations of the Florida panther (*Felis concolor coryi*) have declined in the past decades because of relentless hunting or the loss of suitable habitat and prey populations. Occurring only in Florida, the current estimated population of less than 50 animals places this subspecies in a critical position (Williams, 1978). Although there is a possibility that the panther occurs in Hardee County, the likelihood of this animal occurring within the property boundary during any given period is small. Since the range of an individual panther may be as large as 100 miles, the possibility that the study area is visited by this species should not be discounted. Local reports (MCC, 1977) indicate that panthers may occassionally follow stream courses in the area during yearly range transits.

#### Southern Bald Eagle - Endangered

The southern bald eagle (*Haliaeetus leucocephalus leucocephalus*) is known to occur in Hardee County. Eagles generally are found in riparian habitat associated with the coast or with lake shores. They tend to nest near water bodies where they feed, but some pairs in the interior of Florida nest a considerable distance from open water (Peterson. 1978).

No bald eagles or their nests were seen or have been reported from the proposed site. Although the site could potentially support bald eagles. it is by no means a typical habitat. The areas of open water are small, and eagles tend to prefer larger expanses of open water. If eagles occur on the site, they are probably visitors and do not nest there.

### Red-Cockaded Woodpecker - Endangered

The historical range of the red-cockaded woodpecker (Dendrocopus borealis) includes Hardee County. This species has declined in numbers in recent years as a direct result of habitat modification. The red-cockaded woodpecker has well defined habitat requirements, nesting only in overmature pines infected with "red heart" disease. These birds are relatively sedentary in nature. Several pairs tend to nest in a single tree and form a colony of two to eight individuals, generally feeding and moving as a unit (Baker, 1978).

The extensive clearing of the pinelands on the site and maintenance of these areas as grazing grounds has greatly reduced the red-cockaded woodpecker habitat on the proposed mine area. However, there are areas with pines which are large enough to support red-cockaded woodpecker colonies on the site. Whenever these areas were encountered during the field efforts, the trees were closely examined for red-cockaded woodpeckers, and none was observed.

The Florida Committee on Rare and Endangered Plants and Animals does indicate that a colony of red-cockaded woodpeckers occurs within 10 to 15 miles of Ona (Baker, 1978). However. the extensive modification of the habitat on the site probably excludes red-cockaded woodpeckers, and none are expected to be present.

### Ivory-Billed Woodpecker - Endangered

The ivory-billed woodpecker (Campephilus principalis) has a historical range which includes Hardee County. Ivory-billed woodpeckers require extensive mature stands of lowland hardwoods. These large birds are very intolerant of man's activities, and the extensive modification of the habitats on the site for agricultural purposes virtually assures that no ivory-billed woodpeckers would be present (Texas Instruments, Inc., 1978). There have been no confirmed ivory-billed woodpecker sitings in many years, and most authorities believe that this species is extinct.

### Arctic Peregrine Falcon - Endangered

The Arctic peregrine falcon (*Falco peregrinus tundrius*) is known to winter throughout Florida. The wintering populations of peregrines arrive in September or October and depart from March to May. The wintering peregrine requires an abundant and dependable supply of birds for food as well as perching sites for feeding and roosting. Impoundments and marshy lakes may attract wintering peregrines. DDT is credited with causing the population crash of this subspecies of American peregrine falcons in the continental United States during the last 25 years, although evidence suggests that the Arctic peregrine falcon population is considerably more stable (Snyder, 1978).

No Arctic peregrine falcons were observed on the site. The large, marshy areas on this site do provide habitat suitable for peregrine falcons; however, falcons in Florida tend to winter near the coast where large concentrations of shore birds are more common.

### American Alligator - Threatened

The American alligator occupies marshes, lakes, swamps, and almost every other aquatic habitat in the State of Florida. Officially listed as "threatened" in Florida, the alligator has become increasingly common in recent years. Apparently, alligators are common on the site, occurring in nearly every aquatic habitat productive enough to support them. Alligators were observed on the site in both Oak and Brushy Creeks, in several marshes, and in two cattle watering ponds (Figure II-11).

### Eastern Indigo Snake - Threatened

The eastern indigo snake is known to occur on the proposed site (Figure II-11). Although often associated with gopher tortoises, this large, heavy-bodied snake is actually characteristic of fairly moist habitats such as pine flatwoods and the tropical hammocks of south Florida. When found in drier environments, indigo snakes are subject to desiccation and invariably seek shelter in burrows of the gopher tortoise. The habitat provided by the tortoise burrows appears to be critical for the survival of indigo snakes in areas of limited moisture (Kochman, 1978). Any environmental disturbance which threatens the gopher tortoise will also affect the survival of the indigo snake. This large snake has a very mild disposition, and it has been exploited heavily by reptile collectors in the past, although protected throughout Florida.

Only a single indigo snake was seen during the field surveys. However, suitable habitat for them is common throughout the study area, and it is almost certain that a resident breeding population occurs on the site.

### 3.4.2.2 State Listed Species

### Wood Stork - Endangered (Candidate for federal List)

The wood stork (Mycteria americana) is a large wading bird which feeds along shorelines and in fresh water marshes. It requires a greater abundance of fish than do most of the other waders and is a gregarious species which characteristically roosts and nests in cypress or mangrove swamps. Its present status is primarily related to loss or alteration of suitably productive wetland feeding habitats.

In 1972 and 1973, nesting rookeries occurred approximately 20 miles to the south of the Hardee County site in Desoto County and approximately 40 miles to the northwest in Hillsborough County (Ogden, 1978). According to the FCREPA, wood storks routinely travel distances as great as 40 miles between roosting/nesting sites and feeding areas (Ogden, 1978). Thus, while no roosting or nesting activity was detected on the site, the large marshes and the more productive streams and ditches are known to be frequented by feeding wood storks. Wood storks were seen feeding on several occasions and were commonly observed flying over the site.

### Osprey - Threatened (Appendix II)

Ospreys (Pandion haliaeatus) are known to occur in Hardee County, but none was observed on the site during the field surveys. Two ospreys were observed near the town of Zolfo Springs feeding in a park lake, 10 to 12 miles from the site.

Although listed as threatened by both the federal and state governments, the osprey is only marginally threatened in Florida. The major reasons for this bird's decline elsewhere appear to be reduced nesting success due to pesticide accumulation and habitat disruption. No samples of osprey eggs or adults from Florida have shown pesticide levels which were high enough to inhibit nesting success, and in many parts of the state, successful nesting is common (Ogden. 1978).

Ospreys feed almost exclusively on fish and generally nest in trees near bodies of water which could provide this food. The proposed site does provide habitat suitable for osprey nesting, although ospreys generally prefer areas adjacent to larger bodies of water than those found on the site. No osprey nests were observed during the field investigations.

### Gopher Tortoise - Threatened (Appendix II)

Although the gopher tortoise is a locally common species, in central Florida the combination of extensive land modification for citrus growing and urban development have markedly reduced the number of tortoise colonies. Gopher tortoises require dry, well-drained soils for burrow construction, and these same soils are in high demand for urban development. The most important aspect of gopher tortoise life history is the construction of the burrow, which is occupied semi-permanently by both the tortoise and up to three dozen commensal species. Although these commensal species include the threatened indigo snake, most of them are invertebrates (Auffenberg, 1978).

Gopher tortoise burrows are common throughout the study area. The two xeric hammocks (Figure II-11) appear to be heavily utilized, although burrows also occur in most of the upland habitats on the MCC site.

Florida Black Bear - Threatened

The presence of black bears (Ursus americanus floridanus) has been verified in Hardee County, and the range of one population includes the eastern portion of the study area (Layne, 1978a). The preferred habitat of the Florida black bear is thick, nearly impenetrable vegetation. Any occurrence of this species within the study area is probably confined to the wooded swamps, with lesser utilization of other habitats during nocturnal foraging trips. Aside from persecution by beekeepers and land owners, black bears have suffered recent population decreases because of habitat modification. There have been no recent reports of black bears on the study site, and these animals are not expected to occur with any regularity.

Sherman's Fox Squirrel - Threatened

The longleaf pine-turkey oak sand hills habitat of peninsular Florida is the preferred habitat of Sherman's fox squirrel (Sciurus niger shermani). However, the lumbering and conversion of sand hills to citrus groves has induced an increased utilization of marginal habitats and a corresponding population decline of this subspecies. Although the FCREPA includes the northeastern corner of Hardee County as the limit for the southern range of this animal, individuals were recently cited about 25 miles further south in Desoto County (MCC, 1977), and their presence in that region has been confirmed (Ehrhart, 1978).

Sherman's fox squirrels were seen several times on the MCC property (Figure II-11). They do not appear to be present in very large numbers, although a breeding population probably does exist.

## Florida Mouse - Threatened

The Florida mouse is the only mammal species restricted entirely to Florida and has one of the narrowest habitat ranges of any mammal species in the state (Layne, 1978a). Its primary habitat is sand pine scrub in an early successional stage, but it occasionally does occur in longleaf pine/turkey oak and slash pine/turkey oak communities.

The two xeric hammocks on the study site provide the only habitat suitable for the Florida mouse. Small mammal trapping was not undertaken, and no Florida mice were seen. However, this mouse often occurs as a commensal in gopher tortoise burrows, which are common in the xeric hammocks. If present, the mouse would occur only in relatively low numbers due primarily to the small size of the suitable habitat.

## Audubon's Caracara - Threatened

Audubon's caracara (Caracara cheriway audubonii) is a bird of open, dry country and is typically found in prairies containing scattered cabbage palms and wet areas. The present range of the caracara includes the eastern two-thirds of Hardee County, and recent sitings have been made within 5 miles of the proposed site (Layne, 1978b).

Caracaras take living prey, but they also feed on carrion and can commonly be seen in the air with vultures. Since abundant habitat suitable for caracaras exists on the proposed site, particular emphasis was placed on finding evidence of the caracara on the property during the field work. All flights of vultures were examined with binoculars, but no caracaras were seen on the site.

The caracara is a western species which has only a small, disjunct population in Florida. If caracaras are present on the site, they are there only in very low numbers.

Florida Scrub Jay - Threatened

The Florida scrub jay (Aphelocoma coerulescens coerulescens), is a western species which has a disjunct population in Florida and extremely specific habitat requirements. They are very sedentary in nature and reside permanently in oak scrub consisting of myrtle oak, chapman oak, and live oak interspersed with saw palmetto and scattered sand pine. Scrub jays feed on a variety of invertebrates, but the bulk of the fall and winter diet appears to be made up of acorns.

This subspecies readily adapts to the presence of man and becomes very tame if undisturbed. However, its very specific habitat requirements and sedentary nature have contributed to a recent decline in its population. As more land is cleared for development, the species is restricted to ever smaller amounts of habitat. It is intolerant of such disturbances since scrub jays do not readily relocate even if areas of suitable habitat can be found. Additionally, the bird has an advanced social system which nearly eliminates the possibility of displaced individuals breeding, even if they are relocated in nearby sandhill areas (Woolfenden, 1978).

The FCREPA indicates that the scrub jay is not found in Hardee County (Woolfend, 1978). However, during the field work in April 1980, a single individual was observed in the xeric hammock located in Section 22 West (Figure II-11). Since only a single bird was seen, it is possible that no resident breeding population is present on the site even though the xeric hammock could support scrub jays.

## Southeastern Kestrel - Threatened

The southeastern kestrel (Falco sparverius paulus) is considered threatened in Florida. Kestrels are common throughout Florida especially during the winter. The southeastern subspecies is virtually impossible to distinguish from other species in the field. A bird of open pine forest, the kestrel feeds on large insects and small rodents. Recently, members of the southeastern subspecies have declined in numbers in parts of Florida, but the causes and the magnitude of this decline are not known (Wiley, 1978).

The range of the southeastern kestrel includes all of Hardee County. However, during field surveys in April 1980, no kestrels were seen on the site. Since only the resident subspecies is present during the summer, the lack of sitings during that period indicates that this subspecies is probably not present on the site, although suitable habitat for kestrels is present. Presently, no members of the southeastern subspecies of the American kestrel appear to be resident on the site.

## Florida Sandhill Crane - Threatened

The Florida sandhill crane is a bird of wet prairies and marshes although it feeds in low-lying pastures and shallow lake margins. Nesting usually occurs in the shallow water of lakes and open marshes. The Florida sandhill crane is very sedentary in nature and, if not molested, is relatively tolerant of humans. As with all cranes, the Florida sandhill crane has an extremely low reproductive potential. Suitable habitat for the Florida sandhill crane exists in many of the wetland areas of the proposed site, and cranes were observed several times during the field efforts. At least one pair of sandhill cranes was seen nesting in a small marsh in Section 24 (Figure II-11).

## Sand Skink - Threatened

The small sand skink (Neoseps reynoldsi) occurs in Hardee County within the general area of the proposed site. Sand skinks occur in loosely-packed, sandy soil of the central Florida ridge, primarily in those areas covered with sand pine scrub forest. This species lives below the surface, almost always in St. Lucie fine sand (Christman, 1978). Little, if any, of this habitat type is present on the proposed site, and sand skinks are not expected to occur there.

## Florida Gopher Frog - Threatened

An inhabitant of xeric communities, the nocturnal Florida gopher frog (Rana aerolata aesopus) avoids the extreme daytime temperature of these dry habitats by living in the burrows of other animals, primarily gopher tortoises. Since it is very commonly found in gopher tortoise burrows, the well-being of this species is protected by the same factors affecting the burrowing tortoises. Gopher frogs breed in marshes which are often a great distance from their burrows. Thus, their status in a given area is also affected by any alteration or removal of wetland habitats. There is a high probability that this species occurs in suitable habitats within the study area, but Florida gopher frogs were not seen during any of the field efforts.

## Other Species

In addition to the above endangered and threatened species, the FCREPA lists 21 other species that range into Hardee County. These species are listed in categories designated as: status undetermined, rare, or species of special concern. Eight of these species were present on the site; these were: the common egret (Casmerodius albus), snowy egret (Egretta thula), Louisiana heron (Hydranassa tricolor), little blue heron (Florida caerula), white ibis, glossy ibis (Plegadis falcinellus), black-crowned night heron (Nycticorax nycticorax) and least bittern (Ixobrychus exilis) (Table II-20). Most of these species are probably resident and have breeding populations which use the various habitats provided by the site.

# 4.0 ECOSYSTEM DYNAMICS

To more fully describe the complex habitats associated with the proposed mining, clay storage, and reclamation activities on the MCC property, an ecosystem approach was utilized. This method of habitat description has been utilized by the U.S. Fish and Wildlife Service (Ecology Consultants, Incorporated, 1978) and provides a method of visualizing the major interactions that occur within an ecosystem.

## 4.1 GENERAL

The ecosystems characteristic of the MCC property were identified through field and literature investigations (Section 3.0), and the data were used to develop generalized systems diagrams for the major ecosystem types on the site. These diagrams (Figures II-13 through II-18) use a simplified form of the energy language symbols (Figure II-12) developed by Odum (Odum and Odum, 1976 and Snedaker and others, 1969) to illustrate conceptually the major components and interactive processes which control the structure and function of most of the systems on the MCC site. The diagrams are necessarily generalized and concentrate primarily on key ecological relationships within systems as well as significant import and export flows.

A brief description of the dynamic process characteristics of each major habitat type on the MCC property is presented below, with references to specific portions of appropriate energy diagrams referenced by numbers enclosed in brackets.

### 4.1.1 Swamp

Swamp ecosystems are strongly dependent on water as a source of energy and for control of many ecological processes (Figure II-13). Stream flow and back flooding [1] carry organic materials and nutrients into the swamps as a supplement to internal vegetative production [2] and decomposition [3]. Under high water conditions, peat forms, raising the surface elevation and retarding flooding [4]. When water levels drop and oxygen becomes available, peat and other organic matter may decompose [5] or even burn [6], thereby recycling nutrients internally. The water level also controls the migration of animals [7], both into and out of the swamp.

Ditching draws water from shallow aquifers and accelerates surface drainage [8], thereby affecting many of the processes referred to above. Succession to upland conditions may result if ditching completely removes the shallow aquifers from the habitat. During periods of drought, the water table, rather than surface water, may support hydrophytic vegetation [9]. The development of a dense overstory limits the extent and types of understory species. Finally, surface flow may transport both organic matter and inorganic nutrients out of the swamp [10].

### 4.1.2 Marsh

The system diagram of the marsh (Figure II-14) is very similar to that of the swamp. The vegetation [1] is normally less diverse than in the swamp because of the stress of nearly continuous surface flooding. Fire more frequently affects the peripheral marsh [2], which may also be subject to cattle grazing [3]. Otherwise, processes shown in Figure II-14 are very similar to those presented in Figure II-13.

### 4.1.3 Mesic Hammock

Mesic hammocks (Figure II-15) are controlled by soil moisture conditions [1] rather than by surface flooding. Some hammocks on MCC property, however, are situated within the floodplain of creeks and thus occasionally receive imports of organic matter and nutrients [2]. The accumulation of organic matter on the ground and in soils slows the rate of evapotranspiration [3] and also of percolation [4] to the water table. Low soil moisture levels increase the chance of fire [5] which consumes both live vegetation and dead organic matter, recycling nutrients more directly than by normal decomposition processes [6]. Development of an overstory provides selective competition on understory species by shading [7]; understory plants may also be subject to cattle grazing [8] as well as native consumers [9].

### 4.1.4 Xeric Hammock and Palmetto Range

The xeric hammock ecosystem (Figure II-16) is similar to that of the mesic hammock except that moisture is more likely to be a limiting factor to the internal processes in xeric hammocks. Rainfall [1] is the primary source of water in this system since little or no back flooding or surface runoff occurs. Organic matter is frequently consumed by surface fires [2] and therefore cannot effectively slow the loss of soil moisture by evaporation [3] or percolation [4], which is especially significant in sandy soils. Because of their frequency and relative coolness, surface fires usually destroy only the understory [5], leaving only relatively fire tolerant trees such as turkey oak and longleaf pine. Nutrient cycles [6] are usually nearly closed, with little export to other systems.

Palmetto range may be intermediate between mesic and xeric hammocks in soil moisture content. Left to natural succession, the ultimate type of mature ecosystem that develops is dependent on soil conditions and potential sources of water.

### 4.1.5 Pasture Land

Pasture land differs from xeric and mesic hammocks principally in the degree of manipulation by man (Figure II-17). Fertilizers [1] may be applied to supplement natural nutrient stocks; high productivity grasses [2] may be planted to compete with native species. Herbicides or other stresses [3] may be applied to native grasses. Other measures may also be taken to eliminate the native faunal species [4] which compete with cattle for the available vegetation. Food supplements [5] may be given to the cattle during periods of low primary production. In return for these subsidies, the system provides milk [6] and meat [7] to the farmer. It may also export excess nutrients [8] and wastes [9] in rainfall runoff.

### 4.1.6 Creeks

The presence of flowing water in creeks (Figure II-18) creates an ecosystem much different from those previously described. Most of the organic matter is imported into the system from adjacent or upstream habitats [1]. Internal primary productivity is limited to rooted aquatic vegetation and algae [2]. Most of the biological activity occurs in the consumption of organic matter [3] by various types of aquatic life, including benthic invertebrates and microbes. These heterotrophic processes consume dissolved oxygen [4] from the water; low oxygen concentrations may, on occasion, be a limiting factor to further organic processing. The existence of pollutants in the water column may stress both primary producers and consumers [5]. There is a continual import and export [6] of matter and energy through the system, so that, normally, flows of energy and biomass are high relative to standing stocks. This is the reverse of the situation which exists in the terrestrial systems (especially the hammocks) and even from that of the swamp and marsh.

### 4.1.7 Specific Site Ecosystems

Some of the ecosystems on the MCC site can best be described in terms of a combination of the individual habitats described in previous sections. Those composite ecosystems which occur along Brushy and Oak Creeks are shown by box diagrams on Figures II-19 and II-20; the locations of the five important systems groupings (Systems A through E) depicted on these figures are shown on Figure II-7.

The Brushy Creek wetlands (Figure II-19) are relatively small in comparison to the Oak Creek systems; they are located near the northern site boundary where Brushy Creek enters the property. The dominant ecological features of this system (System A) are: a mesic hammock affording allochthonous input into Brushy Creek in the form of leaf litter; extensive pasture land with associated runoffs from cattle wastes and grasses; and scattered marshes, most of which are directly contiguous to Brushy Creek. The system is dominated by mesic hammock, with most of the aquatic system exposed to high sunlight. As a result, the creek is characterized by thick growths of submerged and emergent macrophytes along much of its length. Most of Brushy Creek has been channelized, with spoil banks along both sides of Brushy Creek. As a result of these societal perturbations, many wetlands in this section are largely isolated except during very wet seasons.

The Oak Creek wetlands (Figure II-20) are much more complex in their interactions with the primary stream flow than are those associated with Brushy Creek. These wetlands generally provide high habitat diversity in the headwaters of Oak Creek, where mean annual flows are less than 5 cfs, and low diversity in the lower portions of the property where flows exceed 5 cfs. The transport of organic components into Oak Creek in the northern systems (B, C, and D) is generally allochthonous, primarily as leaf litter; it is autochthonous in the southern system (E), primarily from growth and decay of water hyacinths. Most of the marshes in Systems D and E are directly contiguous to Oak Creek. Each of the systems represented on Figure II-20 is described below.

System B - This is a swamp-dominated ecosystem, with man-made drainages providing additional open water area; other societal perturbations north of this system (e.g., a citrus grove, pastures, and a road) have probably reduced surface water transport into this area from former levels. A mesic hammock fringes this swamp, as is characteristic for most swamps on the site. A mesic area also occurs in the center, resulting in highly diverse biotic conditions for this system.

System C - This system is similar to System B, though considerably smaller. Although it has probably been hydrologically stressed by nearby societal modifications, it still contains a high diversity of habitats.

System D - This large system is highly diverse and contains branching channels associated with Oak Creek. Interactions of import and export between the various components of this system appear to be very complex. In addition, the swamps and marshes in this area are probably important modifiers of water quality and flow characteristics in Oak Creek. The direction of energy flow from this system is directly related to the amount of rainfall; during high water, export is shunted to Brushy as well as to Oak Creeks.

*System E* - This marsh-dominated system is adjacent to a section of Oak Creek that has been channelized and straightened. The direction of export, as in System D, is affected by the amount of precipitation, and, during high water, materials are transported to the south and west (Brushy Creek) as well as to the east (Oak Creek). During low water periods, dredge spoil isolates many of the wetlands associated with Oak Creek, causing stagnant and nearly anaerobic conditions.

## 5.0 IMPACTS

The biological and abiological components of ecosystems on the MCC property that might be affected by specific phases of the proposed mining and clay storage plans, as approved in the Florida Development Order, are listed in Table II-21. In the following discussion, emphasis has been placed on wetlands and streams with greater than 5 cfs mean annual flow since these ecosystems are likely to be the most sensitive to mining activities.

### 5.1 TERRESTRIAL ECOSYSTEMS

The majority of the MCC site (approximately 80 percent) is comprised of terrestrial upland communities that are either heavily disturbed or are not generally considered ecologically sensitive; these communities include pasture land, palmetto range/pine flatwoods, and a citrus grove. Table II-21 lists the total acreage of the major habitats that would be affected by the proposed activities. Approximately 8,182 acres of upland habitats on the MCC property would be directly affected by the clearing or covering of vegetation during the course of mining operations and plant construction. However, under the proposed mining schedule, only certain blocks of land would be disturbed at any one time, and much of the site would remain in a natural state for several years after mining was initiated.

The most apparent result of mining and reclamation activities would be a substantial loss of the few natural upland habitats which are present on the site and a gain in improved pasture. This represents a long-term impact on the upland communities, since it is unlikely that these habitats would re-establish themselves to their original species composition. Mesic hammocks and xeric hammocks would probably be permanently eliminated where the soil was radically altered by mining or clay storage. Fires are generally controlled around areas of increased human activity, such as the natural areas associated with the proposed project. Prolonged fire suppression would allow xeric hammocks to become more mesic and would constitute an irreversible impact.

The loss of some upland habitats would directly affect wildlife populations that use these systems, although undisturbed areas would provide some refuge during mining activities. However, all wildlife habitats on the site are probably at or near their carrying capacities, and animals from newly disturbed areas are not likely to become permanent residents of undisturbed areas.

During mining, lowering of the ground water table would have an indirect effect on the nearby natural communities which are not scheduled to be mined. The decrease in the ground water level should be temporary since the water table would be restored as the mined out pits are filled during reclamation. Water tables are expected to closely approximate the pre-mining levels after reclamation. The expected impact of dewatering activities would be similar to that experienced during a severe drought. If rainfall were above normal and frequent throughout the growing season, the lowered water table might have little or no effect on existing vegetation. If rainfall were subnormal or irregular, vegetative production would be reduced, and some plants might remain dormant for a year or more. Normal growth in the upland communities would be expected to resume as soon as normal water table levels were attained, just as growth resumes without serious effect after a severe, natural drought.

Changes in air quality as a result of mining operations might also affect the terrestrial communities on the MCC site. Levels of dust and other air emissions would increase above ambient during mining operations, but the only component likely to affect plants or animals is fluoride. Other emissions, such as $SO_2$ and radionuclides, would occur at such low levels as to produce no discernible impact on the biota. Gaseous fluorides might be generated during mining operations in minor quantities from rock dryers and waste process water ponds (USEPA, 1976). Particulates containing fluorides might also settle on vegetation and, if soluble, be transported into plant tissues.

Wildlife and domestic animals are most likely to be affected by foraging on foliage containing fluoride particulates. Generally, the normal rainfall in the region would cleanse the vegetation of particulates at frequent intervals, thereby reducing potential fluoride toxicity. During periods of reduced rainfall, however, fluoride concentrations can reach levels which have adverse effects on animals (USEPA, 1978). After entering the soil, these fluorides would be scarcely, if at all, absorbed by roots.

The effect of atmospheric fluoride on plants becomes more severe as the concentration, length of the exposure, or frequency of exposure becomes greater. Other factors which influence the susceptibility of different plant species to fluorides are: the edaphic soil moisture regime, mineral nutrient status, soil temperature, general age of the plant, plant vigor, and genetic sensitivity of the individual species. Thus, it is extremely difficult to predict the reaction of the local flora to potential increases in fluoride levels resulting from MCC's activities. However, some plants have been divided into sensitive, intermediate, and resistant categories (Jacobson and Hill, 1970; Applied Science Associates, Inc., 1976). Citrus plants are generally categorized as intermediate in sensitivity, indicating a relative tolerance to increased levels of fluoride. Besides citrus, plants which are considered intermediate to resistant include elm, elderberry, red mulberry, Johnson grass, goldenrod, and oaks. Examples of sensitive flora are the azalea, rhododendron, violet, privet, St. John's wort, and smartweed. Pines are also relatively sensitive.

The maximum 24-hour average onsite, ambient fluoride level was 9.97 $\mu g/m^3$. Levels of fluoride emitted are expected to be low and would have negligible, short-term effects on even the most sensitive plants. However, due to the extended nature of the operations, the long-term effects of fluorides on local vegetation vigor would be monitored so that symptons of fluoride stress could be detected at an early stage, if they occurred.

Offsite impacts to adjacent biological communities would be largely confined to those wetlands on the Farmland property which are highly contiguous to aquatic systems which would be eliminated during the course of MCC site development. This is true for the wetlands south of Section 5 and the area referred to as the Oak Creek Islands. It is uncertain how slight alterations in hydroperiod would affect the wetland functions of these areas. Impacts would likely be more significant during drought periods, decreasing edaphic moisture regimes even further. This could, in turn, result in changes in the floristic composition of the wetlands toward species better adapted to mesic conditions. Return to the normal hydrology of these systems would, however, restore these communities approximately to the same floristic composition, since it is extremely unlikely that all of the reproductive propagules (rhizomes, seeds, etc.) of the original wetland plants would die during these occasional periods of stress.

Offsite impacts on wildlife would be related directly to the displacement of animals on the MCC tract. As mining operations continued, mobile animals would enter nearby habitats which are probably at carrying capacity. These invaders would act as a stress on the existing communities, displacing them temporarily from equilibrium. However, the populations should stabilize within a short time, reaching levels comparable to those which existed prior to the invasion by displaced individuals.

The functional value lost by removal of terrestrial habitat would depend upon the area affected. Most of these upland losses would be of importance primarily to the cattle that graze on the site, but adequate replacement with additional forage areas should occur soon after reclamation. The only upland habitats of unique value that would be lost are some of the xeric hammocks in the northwest sections of the property. These habitats afford refuge for several species of state and federal interest and are not proposed for replacement during reclamation.

## 5.2 WETLANDS AND AQUATIC ECOSYSTEMS

Many of the wetlands on the MCC property, as well as the water bodies which are functionally related to them, can be characterized as ecologically important habitats (Sections 3.2 and 3.3). The evaluation of potential impacts by the proposed mining operation as approved by the Florida Development Order, assumes that mining would either be delayed or excluded from certain areas to provide protection for the more important habitats. In addition, MCC would avoid disturbance to another 440 acres for the duration of the project; this would provide additional seed sources during reclamation.

### 5.2.1 Wetlands

The proposed mining and clay storage plan would directly affect 2,540 acres of existing fresh water swamps and marshes (Table II-21) and 4 miles of 5 cfs stream beds. Some of these land/water interface systems are ecologically important, and their loss, based on the criteria developed in the Central Florida Phosphate Industry Impact Statement (USEPA, 1978), would result in significant declines in biota, changes in hydrology, and/or deterioration of water quality. The loss of 2,540 acres of swamp and marsh habitats would adversely affect many of the animal communities on the site. The MCC site is used by a diverse avian fauna, many of which would migrate out of the area to other fresh water marshes and swamps. Migrants which attempted to return to undisturbed habitats would act as a stress upon the resident individuals since communities unaffected by mining would probably be near their carrying capacity. The result of these displacements, therefore, would be a decrease in some animal populations.

Additional stresses upon the plant and animal communities on the site would result from the indirect effects of mining and mining activities. The most important of these indirect impacts would be those associated with pit dewatering during actual mining, which could lower the water table of adjacent ecosystems that were not scheduled for mining. During dewatering, the lowered water table would simulate localized conditions of prolonged natural drought. If rainfall were subnormal during the growing season, this unnatural drought could stress sensitive vegetation and reduce the densities of the animal populations which use the affected wetland habitats. However, most wetland communities would have the capacity to become re-established where peaty acid substrates and suitable hydroperiods were attained.

An additional effect of dewatering would be to increase the potential for swamp fires. Such fires would not have appreciable, long-term effects except where fire-susceptible hardwoods were destroyed. The possibility of a widespread fire is remote since fire would be unable to spread across roads, mining pits, or other clearings devoid of fuel.

Erosion of soil into wetlands is another indirect impact which could occur as a result of vegetation removal by the mining operation and piling of overburden in steep spoil banks. However, because the mined areas would be below grade, and since perimeter dikes would be built around the actively mined areas, most of the runoff should be contained in the mine pits.

Pipelines, transmission lines, roads, and other structures that might be built across wetlands would produce short and long-term disturbances. Pipelines might temporarily impede the movement of organisms and, if spills occurred, result in localized habitat damage. Walking of draglines across wetlands and streams might produce extended impacts from habitat disruption and sediment runoffs, but these effects would generally be reversible. Roads, transmission lines, and other permanent structures would probably produce permanent effects, such as the usual construction impacts (e.g., noise and sediment runoff), and subsequent impacts affecting migration of vertebrates (e.g., birds striking transmission lines, noise and emissions from road activity, and road kills).

The primary functional values of wetlands on the MCC site are hydrological, to include water detention and nutrient export, and habitat diversity. The effect of the loss of wetlands and the concomitant loss of these functions, would depend upon the spatial and temporal relationship of these losses.

In general, the loss of non-forested wetlands (marshes) offering little hydrologic interaction with flowing water bodies (particularly, Brushy and Oak Creeks) should result in the least loss in wetlands functions. These relatively isolated marshes should be readily reclaimed and, because of the experimental and undisturbed marshes present on the site, adequate seed sources for plants and animals should be available to assure losses would be temporary. The loss of large contiguous marshes would not occur until late in mining life; these areas would be replaced with similarly functional wetlands prior to mining. In summary, loss of 2,085 acres of marshes, most of which have minimal hydrologic function, would be replaced at the conclusion of mining activities with 1,620 acres of marshes (Table II-22), most of which would be contiguous with Brushy and Oak Creeks.

The loss of forested wetlands on the MCC site would result in the most important functional losses, primarily as a result of decreased overall habitat diversity. The uniqueness of these swamps on the site is largely because most of the site is presently in pasture or palmetto/pine rangelend. The largest tracts of swamps, however, would not be mined until adequate demonstration had been provided to show they could be replaced. In summary, assuming that swamps of similar structural diversity and habitat value would result from the proposed reclamation, the proposed plans would produce a net decrease in swamps from 490 acres to 425 acres (including 35 acres unaffected throughout mine life); the overall functional values of these systems on the site should be increased by the proposed action.

### 5.2.2 Streams

Approximately 4 miles of streams with greater than 5 cfs mean annual flow would be mined under the proposed mining plan (Table II-22).

About 1.3 miles of Brushy Creek and 2.9 miles of Oak Creek would be affected by mining operations. Large segments of these habitats have already undergone modification through channelization and straightening and do not presently contain significant quantities of contiguous wetlands that could be important in enhancing water quality. Development of alternate stream channels with contiguous wetlands prior to mining each section and stabilization with vegetation and riprap would reduce the impacts of relocation and enhance development of a stable aquatic ecosystem in the new stream. Although the diversion of stream flow into the new channels prior to mining of the stream would enable relocation of the majority of fish and mobile benthic forms, non-mobile benthic forms such as worms and midge fly larvae would be destroyed. There would also be some loss of fish and benthos due to their isolation in stream pockets created after stream flow diversion. The successful recovery of fish communities within diverted sections of the streams would depend primarily upon physical characteristics of stream topography, the development of instream vegetation, and colonization of the stream by benthic invertebrates.

Dewatering activities associated with mining would also affect the existing aquatic biota in the streams on the site by lowering the adjacent water table. In areas where extreme lowering of stream volume occurred, the water bodies could become segmented into isolated pools. The reduction in stream flow would also reduce the transport of benthos and organic materials to downstream systems. The concentration of aquatic biota into smaller stream segments would ultimately cause a reduction in population densities since the size of the remaining habitat would be insufficient to support the standing crop.

Some suspended solids would be transported in the runoff water and could be expected to reach the aquatic habitats on the site. Such erosion would result in short-term effects which would include: smothering of benthic organisms, destruction of spawning areas, and abrasion and clogging of fish gills (Cairns and others, 1972). Although the effects of erosion could be reversed following abatement,

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all components of the aquatic community could be altered by increased sedimentation (Muncy and others, 1979), favoring tolerant aquatic species.

The benthic organisms present in the flowing water bodies on the site, particlarly Brushy Creek, comprise communities that provide drifting food for fish in the downstream water bodies off the site. In addition, these invertebrates provide a recruitment function whereby these species constantly drift downstream to recolonize stream substrates such as sediments and snag. The replacement of these functions would be of primary concern in phases of stream recovery that accompany the Farmland mining and reclamation programs. During stream reclamation, streams on the MCC site would be the primary source of aquatic organisms that would be needed to reestablish pre-mining communities.

Removal of forest canopy adjacent to some streams on the MCC property would have several long-term, indirect effects on these aquatic habitats. When the canopy was opened, more sunlight would reach the surface of the streams, resulting in higher temperatures and increased productivity of vegetation, primarily such nuisance plants as water hyacinths. Additional macrophytic development would provide shelter for various aquatic animals, substrate for aufwuchs communities, and foraging areas for fish. In areas where excessive macrophytic growth occurred, the death and decompositon of these plants would result in potentially significant decreases in oxygen through metabolic respiration, with concomitant losses of oxygen-sensitive invertebrates and fish. The slight increase in temperature from increased insolation is not likely to adversely affect any of the species presently occurring in Brushy or Oak Creeks, although high temperatures in isolated pools might reduce oxygen solubility sufficiently to stress some species. As trees and other plants begin growing during reclamation activities, the developing canopy will reverse most of the changes caused by removal of riparian vegetation.

The proposed discharge into Oak Creek from the water recirculating system might contain a number of substances such as clay wastes, phosphate, and flotation reagents, which could adversely affect aquatic biota. The impact of each pollutant would vary, but prolonged discharges could alter the density and diversity of aquatic communities. Section 3.2.1 of the DEIS discusses the changes in water quality that would result from effluent discharges. The parameters that would appear most likely to be altered from existing conditions are: total suspended solids ($\bar{x} = 12$ mg/liter) and oil and grease (75 mg/liter). There would also be very dilute quantities of amines, kerosenes, and other reagents released with the effluent. The potential impacts of organics such as oil and grease and increased suspended solids could result in a decline in filter-feeding organisms, primarily zooplankton, and could interfere with respiratory functions of other aquatic species, including adult fish. However, infrequent discharges of these constituents should result in only short-term impacts. These wastes would also probably enhance populations of the tolerant species now present.

The displacement of streams during mining could result in temporary losses to downstream communities of drifting benthos and fish. Additional losses of allochthonous energy sources, as a result of little vegetation along newly constructed streams, would also affect productivity downstream. The proposed plan, however, includes rerouting only 0.25 miles of streambed in the first four years of mining, with subsequent stream relocation not occurring for 17 to 20 years (Table II-22). Construction of new stream sections a few years prior to the later mining plans, therefore, should provide adequate replacement of vegetation along shoreline. Innoculation of these new sections with benthos and fish from unaffected tracts would then result in minimal losses to downstream communities. In summary, if new stream development includes vegetated littoral zones and increased meandering of streams to replace the largely channelized systems presently on the site, the long-term effects of mining and reclamation should enhance overall habitat value of the aquatic systems on the MCC site.

### 5.2.3 Time-Phased Impacts

The proposed mining, clay storage, and reclamation activities would occur over a period of approximately 44 years. The various phases of the mining plan have been subdivided into approximately four-year segments, as discussed in the ADA/DRI (MCC, 1977). As successive years of the mine plan were completed, many of the previously mined areas would be utilized for clay storage and subsequent reclamation. As a result of the sequence of these activities, the quantitative loss and recovery of ecosystems would vary over the life of the project. To evaluate these events over the history of the proposed project, a series of overlays were developed for each four-year period of the project life, indicating the areas of wetlands and 5 cfs streams affected by mining, clay storage, and/or reclamation (Table II-22 and Figure II-21). Approximately 14 percent of all wetlands to be affected by the MCC project, comprising 36 acres of swamps and 310 acres of marshes, would be lost during the first four years of the project as a result of mining and clay storage activities; in addition, 0.25 mile of 5 cfs streambed in Oak Creek would be lost during this same period (Table II-22). These habitats would be replaced during the later years of the project, with development of wetlands and stream channels, in some areas beginning in the early years of mining activity. Other reclamation activities would follow capping of waste disposal areas. Figure II-21 shows the acres of wetlands lost over the duration of the project and the years when reclamation of wetlands would begin to offset these losses.

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## 5.3 THREATENED OR ENDANGERED SPECIES

Table II-20 indicates the impacts from mining, clay storage, and reclamation activities on species listed by federal or state agencies as threatened, endangered, or otherwise of special status. This list includes only those listed species that are present or may potentially be present on the MCC property. However, there are habitats suitable for all of these species within the region. Of the species known to be present on the site, several might incur long-term losses from the effects of the project, while all would be affected for short periods by temporary loss of habitat and disturbance from mining activities.

Wood storks (endangered, FCREPA and a candidate for federal listing) require feeding areas with high concentrations of aquatic organisms. Before portions of site streams are mined or displaced by clay storage activities, functionally equivalent streams would be established so that there would be only a temporary reduction in aquatic organisms following rerouting of stream beds. Although some of the wetlands on the MCC site that provide prey species would be lost for many years, suitable replacement would eventually be re established. This temporary loss of food resources might reduce the nesting success and result in a decline in wood stork numbers.

The Florida sandhill crane (threatened, FCREPA) presently nests and feeds in wet pastures on the site. Cranes have an extremely low reproductive potential, and reduction of their habitat by the project might adversely affect their population size. Since this species has a limited ability for recovery following population decline, any reduction in numbers could eliminate this animal from the site.

Sherman's fox squirrel (threatened, FCREPA) presently occurs on the site in mature pine forest and mesic habitats which are generally suboptimal for this species. The further stress of limiting the available habitat might result in the elimination of this animal from the area.

A single Florida scrub jay (threatened, FCREPA) was identified on the property during the field investigations. These birds have very specific requirements for scrub oak habitat, most of which would be removed during mining activities. However, because of the advanced social system characteristic of this species, in which several non-breeding individuals help in rearing of the young, and the limited areas of scrub oak habitat on the site, there is almost certainly no breeding population present. In addition, scrub oak habitat is likely to return naturally following mining activity.

Gopher tortoises (threatened, FCREPA) are common on the site, with most upland habitats containing active gopher tortoise burrows. Gopher tortoises have little ability to escape impacts by the various phases of mining activity, and their numbers would undoubtedly be reduced. Suitable habitat for the gopher tortoise would be re-established following mining. However, gopher tortoises have little ability to colonize and are not likely to attain present population size for many years.

Of the federally protected species which were observed or might occur on the site, only the American alligator is common. Alligators (threatened, USDI) can be found in all of the fresh water habitats on the site which are productive enough to support them. During mining, clay storage, and reclamation activities, most of the alligator habitats on the site would be disrupted. However, alligators have proven to be extremely resilient and rapidly recover to normal population size following societal disturbances. Since most of the habitats suitable for alligators are scheduled for reclamation, there are not expected to be any long-term impacts to the alligator population on the MCC site.

The eastern indigo snake (threatened, USDI) would be directly affected by all phases of mining activities, and many might be killed or captured. Following reclamation of suitable habitats, some indigo snakes might successfully recolonize the site, but because of their historically low reproductive success, it is anticipated that a relatively long-term reduction in numbers of indigo snakes would result from mining activities.

Of the remaining species listed as threatened or endangered by the USDI, none are likely to occur on the site except as rare or temporary visitors. The Florida panther (endangered, USDI) might occur in the area, but there have been no recent confirmed sitings of this species near the site. The ivory-billed woodpecker (endangered, USDI) is most likely extinct, and is unlikely to occur on the site. The red-cockaded woodpecker (endangered, USDI) requires mature pines. Although some mature pines occur on the site, a thorough survey for nests of this bird in likely areas disclosed no evidence of their presence. The Arctic peregrine falcon (endangered, USDI) and the bald eagle (endangered, USDI) might be occasional visitors to the site, but neither species was observed. Surveys for bald eagle nests were also conducted, but none was found.

## 6.0 MITIGATION OF IMPACTS ON ECOSYSTEMS

In general, less mitigative effort will be required when habitats are affected which are of low ecological value or which can easily be replaced, lost, or disturbed than when more valuable habitats are impacted by mining operations. Habitats of relatively low ecological value cover about 75 percent of the MCC property and include palmetto range, pasture, and pine flatwoods. More biologically important habitats, including primarily wetlands and aquatic systems, cover about 25 percent of the MCC site. The following discussion relates primarily to mitigation that is planned or would help reduce or delay impacts on areas that are particularly important from an ecological standpoint.

### 6.1 TERRESTRIAL

Approximately 3,688 acres of upland habitats would be unaffected by mining, clay storage, or related activities (Table II-21). These undisturbed areas would provide refuge for displaced wildlife and would serve as a source of indigenous seed species for natural revegetation during reclamation.

Reclaimed areas would be planted with cover vegetation as soon as possible to reduce erosion. These lands would be planted with species such as Bermuda grass, bahia, and white clover, which rapidly incorporate organic matter and develop topsoil. Hedgerows of native trees would be planted, providing escape cover for wildlife.

Air emissions associated with plant operation would be kept within applicable standards so that protection would be afforded to biota not directly affected by mining.

## 6.2 WETLANDS AND AQUATIC SYSTEMS

The approximately 3,000 acres of wetlands comprise some of the more important biological areas that occur on the MCC site (Figure II-5). However, some of these wetlands have reduced functional value because of their small size or isolation from aquatic ecosystems. Other swamps and marshes on the site afford important habitats to animals or provide significant hydrologic functions; mitigative measures are planned to protect or replace their respective functional characteristics.

In addition to the wetlands on the property, there are two major streams, Brushy and Oak Creeks. Each of these streams has been affected by dredging and channelization. Planned mitigation of mining impacts on streams or suitable reclamation should provide positive impacts on the site's aquatic environment.

### 6.2.1 Wetlands

The type of mitigation of impacts planned for wetlands on the site is dependent upon the location of these systems and their functional importance. There are approximately 440 acres of wetlands on the MCC site that would be unaffected by mining or clay storage. In addition, the approved Florida Development order for the MCC site placed an additional 233 acres into preservation status until satisfactory evidence is provided that wetlands can be reclaimed to a similar functional level as those to be mined. Other possible wetlands preservation scenarios are discussed in Section 2.10 of the EIS. Because of the time-phased nature of the proposed mining and clay storage activities (TSD Section 5.2.3), many additional areas would remain undisturbed for extended periods of time, allowing unaffected wetlands to be utilized for wildlife and vegetation seed sources.

Wetlands which are set aside for preservation would require mitigative measures to protect them from the indirect effects of mining. Planned protective measures for specific wetlands would include delineation of a 250-foot wide, non-mineable buffer zone to reduce noise, dust, and water drawdown impacts on wetland species. During the phases of mining when water drawdown could occur, a water-filled rim ditch would be placed adjacent to the protected wetlands to provide a hydraulic gradient so that normal ground water levels could be maintained. Except in areas where streams would be rerouted prior to mining, wetlands along streams would be protected by actively mining only along one side of the stream at a time. The initial mine pit would be filled before the opposite side of the stream was mined to assure that flow of ground water into adjacent wetlands would never be severed entirely. Wetlands would be protected from erosion by the use of hay bales, screens, and/or settling ponds adjacent to the mining activity. In addition, personnel working near wetlands would be trained to avoid disturbance of indigenous wetlands species.

### 6.2.2 Aquatic Habitats

The two major streams on the MCC site, Brushy and Oak Creeks, have already been affected by dredging and channelization. These would be replaced by streams of higher value by creating contiguous wetlands, removing dredge spoil piles, and providing meandering stream channels. Numerous enhancements of stream and floodplain quality are planned in order to increase the overall productivity and functional value of the aquatic habitats on the MCC site.

A suitable stream reclamation program should avoid channelization or increase in slope, provide for bank stability by using trees where possible, minimize channel reshaping, initiate early seeding of grass in disturbed areas, provide for judicious installation of riprap, and emulate nature in channel form (Nunnally, 1978). An integral part of reclamation of the segments of Brushy and Oak Creeks disturbed by mining would be the selective placement of instream stabilizing elements such as snag and riprap.

Establishment of native trees and other natural vegetation in the new floodplain area would precede actual diversion to enhance stabilization and promote successful development of the new, or final, streambed subsequent to diversion. Revegetation would be initiated by planting grasses and legumes in the final stream floodplain and along the high water channel, followed by the planting of native trees to restore the floodplain to a forested state. Trees would be planted within the newly restructured floodplain, including the high water channel, up to the actual excavation of the new stream channel. Where possible, the types of trees planted would grade from those common to a wet environment adjacent to the stream channel area, such as red maple and sweetgum to more mesic species along the higher slopes of the floodplain, such as live oak and pine.

The impacts of streambed mining on aquatic biota would be minimized by early preparation and stabilization of an alternate stream course. The actual stream diversion would occur before any mining was initiated in the water body. Ultimately, the newly constructed channels would be designed in conformance with natural contours, elevations, floodplains, and gradients, providing aquatic habitats similar to those which occur naturally in the region. Vegetation along stream-beds would provide canopy which could preclude development of nuisance vegetation such as water hyacinth and could also assure a source of nutrient input to the stream system. The modification of flows within this stream system by the reservoir systems developed for the mine could also enhance development of aquatic biota by providing more stable flows and promoting more diverse habitats.

The impact of dewatering due to mining would be reduced by mining along only one side of the stream at a time, by use of an appropriate buffer zone between the mining area and the stream, and by construction of a water-filled rim ditch between the stream and the mine cut.

The increase in stream turbidity associated with most mining activities due to increased erosion would be minimized by diversion of runoff from mined areas into settling areas prior to release to the stream.

### 6.2.3 Reclamation of Wetlands and Aquatic Habitats

Most of the ecological functions of undisturbed forested wetlands are considered irreplaceable under current state-of-the-art reclamation methods. However, this general lack of evidence for successful wetlands reclamation does not preclude the advent of rapid technological progress toward complete restoration of previously mined swamps. Once the needed soil and nutrient requirements, hydrologic regimes, and successional interactions of the necessary woody vegetation are identified, a swamp canopy could be formed within which natural successional processes could take place. These events would result in an increase in organic soil, species diversity and richness, and overall wetland value of the regional drainage system.

One feature of the proposed MCC wetlands restoration plan, as described in Section 6.2.1, is that evidence for successful marsh and swamp restoration would be provided through on-site experimental plots prior to mining of certain wetlands. These experiments in wetlands restoration would contribute to the body of knowledge necessary to advance wetland restoration technology. Many wetlands which presently have little or only intermittent connections to on-site streams could be recreated within stream floodplains and have higher contiguity to these water bodies. This would increase the wetland value of the floodplain, especially where pasture or disturbed mesic hammock was replaced by marsh or hardwood swamp.

Reclamation activities would begin after mining and waste clay solidification on individual tracts (Table II-22). The regrowth of fresh water swamps would be slow, with several decades of tree growth required before a mature forest could develop. Reclamation efforts would be greatly aided by the transferral of peat and organic muck from the wetlands to be mined directly to the reclamation sites. Stockpiling of these materials would be avoided to minimize oxidation and degradation of the wetland soil. Identification of important seed sources would be made prior to mining so that these could be used in wetland restoration. Tree establishment might be difficult in places because of the inability to stabilize the substrate of the restored floodplain. The initial cover would likely resemble that which presently exists in the floodplains of the major streams, rather than those of bayheads. Sweetbays, swampbay, and other species that are more common in bayheads would probably be uncommon in reclaimed areas until peaty acid substrates developed.

Fresh water marsh development should be more rapid than development of hardwood swamps. Emergent and shallowly submerged aquatic plants would readily invade borrow pits, clay settling ponds, and other newly created wet habitats in the region. Cattails might become dominant, with the exclusion of all other emergent species, unless efforts were made to provide necessary inoculant species and create an organic substrate suitable for their growth. Cattail populations would occur in the littoral zones of newly created lakes and would be even more common in the swales and marshes that would be formed by subsidence at the outlet ends of sand-clay land fills. Once established, these dense growths of cattails could persist indefinitely, as long as water levels were seasonally deep enough to exclude willow, buttonbush, and other woody plants.

The recovery of animal populations associated with wetlands would vary with the success of the restoration of these ecosystems. Following the recovery of natural vegetation and the establishment of reproducing populations of insects and amphibians, the reclaimed wetlands would offer suitable habitat for many of the species displaced during mining. Recovery of animal populations would not, however, be as rapid as the recovery of the vegetative community. Undisturbed wetland areas would provide individuals for colonization of the newly established wetlands systems. Colonization of these new wetlands could be sporadic, with some species requiring several attempts before successful establishment of permanent populations (MacArthur and Wilson, 1967).

Stream segments established after mining would be recolonized by aquatic biota from adjacent stream and marsh systems. During the initial stages of development, young floodplain vegetation would provide little detrital input but would allow light penetration. As a result, aquatic macrophyte communities would become well developed but would decline as shading increased with canopy development. The development of riparian vegetation would also increase the detrital input to the stream. The restored stream segments should, therefore, provide improved aquatic habitat in comparison to that available prior to mining activities. This new habitat would also support a more diverse aquatic fauna and sustain or improve the aquatic system downstream of the MCC site.

## 6.3 THREATENED AND ENDANGERED SPECIES

The reclamation plan proposed by MCC would create suitable habitat for all of the protected species which presently occur on the site. Although, in some areas, there would be less habitat than prior to mining (e.g., suitable indigo snake habitat would be reduced), in other areas, the habitats for threatened and endangered species would increase (e.g., alligator habitat would increase). Additionally, the reclamation plan proposes to create some ecosystems not presently found on the site, such as lakes. These lakes would attract protected species such as bald eagles and ospreys which presently do not have suitable habitats on the site.

Since activities are spread over a long time period, some areas would be reclaimed before others were mined. Where possible, MCC would attempt to transfer protected species to newly reclaimed habitat prior to mining activities. Particular emphasis would be placed on the indigo snake and gopher tortoise since these species have limited ability to escape mining activity. To reduce the chance that protected species would be affected by the project, MCC will instruct its employees not to kill any terrestrial species on the site.

## TABLE II-1

## EXISTING COMMUNITY TYPES

| Community | Acres | Percent of Total |
|---|---|---|
| Citrus Groves | 28 | <1 |
| Xeric Hammock | 30 | <1 |
| Swamps | 490 | 3 |
| Mesic Hammock | 770 | 5 |
| Marshes | 2,490 | 17 |
| Pasture | 5,040 | 34 |
| Rangeland | 6,002 | 40 |
|  | 14,850 | 100 |

## TABLE II-2

### SPECIES COMPOSITION OF PLANT COMMUNITIES ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY, HARDEE COUNTY

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| Species | Common Name | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture | Ruderal |
|---|---|---|---|---|---|---|---|---|
| Trees (Overstory) | | | | | | | | |
| *Acer rubrum* | Red maple | | | | X | | | |
| *Carya aquatica* | Water hickory | | | | X | | | |
| *C. glabra* | Pignut hickory | | | X | | | | |
| *Celtis laevigata* | Sugarberry | | | | X | | | |
| *Diospyros virginiana* | Persimmon | | | X | | | | |
| *Fraxinus pauciflora* | Swamp ash | | | | X | | | |
| *Gordonia lasianthus* | Loblolly bay | | | | X | | | |
| *Ilex cassine* | Dahoon | | | | X | | | |
| *Liquidambar styraciflua* | Sweetgum | | | | X | | | |
| *Magnolia virginiana* | Sweetbay | | | | X | | | |
| *Morus rubra* | Red mulberry | | | | X | | | |
| *Nyssa sylvatica* var. *biflora* | Blackgum | | | | X | | | |
| *Persea palustris* | Swampbay | | | | X | | | |
| *Pinus elliottii* | Slash pine | X | | X | | | X | |
| *P. palustris* | Longleaf pine | X | X | X | | | X | |
| *P. serotina* | Pond pine | | | | X | | | |
| *Quercus geminata* | Sand live oak | X | X | X | | | | |
| *Q. hemisphaerica* | Laurel oak | | | X | | | X | |
| *Q. laurifolia* | Diamond-leaf oak | | | | X | | | |
| *Q. nigra* | Water oak | | | | X | | | |
| *Q. virginiana* | Live oak | X | X | | | | X | |
| *Sabal palmetto* | Cabbage palm | | | | X | | | |
| *Salix caroliniana* | Carolina willow | X | | | X | | | |
| *Ulmus americana* | American elm | | | | X | | | |
| Saplings, Shrubs and Woody Vines (Understory) | | | | | | | | |
| *Acer rubrum* | Red maple | | | | X | | | |
| *Ampelopsis arborea* | Peppervine | | | X | X | | | |
| *Ardisia escallonioides* | Marlberry | | | | X | | | |
| *Baccharis halimifolia* | Groundsel-tree | | | X | X | | | |
| *Cephalanthus occidentalis* | Buttonbush | | | | X | X | | X |
| *Citrus aurantium* | Sour orange | | | X | X | | | |
| *Cornus stricta* | Stiffcornel dogwood | | | | X | | | |
| *Crataegus* sp. | Hawthorn | | | X | X | | | |
| *Diospyros virginiana* | Persimmon | X | | X | | | X | |
| *Fraxinus pauciflora* | Swamp Ash | | | | X | | | |
| *Gelsemium sempervirens* | Yellow jessamine | | | X | | | | |
| *Ilex cassine* | Dahoon | | | | X | | | |
| *I. glabra* | Gallberry | X | | | | | | |
| *I. myrtifolia* | Myrtle-leaved holly | | | X | | | | |
| *Itea virginica* | Sweet-spires | | | | X | | | |

TABLE II-2 (Continued)

| Species | Common Name | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture | Ruderal |
|---|---|---|---|---|---|---|---|---|
| *Liquidambar stryaciflua* | Sweetgum | | | X | X | | | |
| *Lyonia ferruginea* | Staggerbush | X | | | | | | |
| *Magnolia virginiana* | Sweetbay | | | | X | | | |
| *Myrica cerifera* | Wax myrtle | X | | X | X | | | |
| *Nyssa sylvatica* var. *biflora* | Blackgum | X | | | X | | | |
| *Parthenocissus quinquefolia* | Virginia creeper | | | X | X | | | X |
| *Persea palustris* | Swampbay | | | | X | | | |
| *Pinus elliotii* | Slash pine | X | | X | | | | |
| *Prunus caroliniana* | Carolina laurel-cherry | | | | X | | | |
| *Quercus geminata* | Sand live oak | X | X | X | | | | |
| *Q. laevis* | Turkey oak | | X | | | | | |
| *Q. nigra* | Water oak | | | X | | | | |
| *Q. virginiana* | Live oak | X | X | X | X | | | |
| *Rhus copallina* | Winged sumac | | | X | | | | |
| *R. radicans* | Poison ivy | | | X | X | | | |
| *Sabal palmetto* | Cabbage palm | | | | X | | | |
| *Smilax* spp. | Greenbriar | X | | X | X | | | X |
| *Ulmus americana* | American elm | | | | X | | | |
| *Vaccinium arboreum* | Sparkleberry | | | X | | | | |
| *Viburnum nudum* | Possum-haw viburnum | | | | X | | | |
| *Vitis rotundifolia* | Muscadine grape | | | X | X | | | X |
| *Ximenia americana* | Tallowwood | | | X | | | | |
| *Zanthoxylum fagara* | Wild lime | | | X | | | | |
| Seedlings and Ground Vegetation (Ground Cover) | | | | | | | | |
| *Acer rubrum* | Red maple | | | | X | | | |
| *Agalinis purpurea* | Purple gerardia | | | | | X | | |
| *Alternanthera philoxeroides* | Alligator weed | | | | | | | X |
| *Ambrosia artemisiifolia* | Ragweed | X | | | | | X | X |
| *Ampelopsis arborea* | Peppervine | X | | X | X | | | X |
| *Andropogon* sp. | Broom-sedge | X | X | | | | X | |
| *A. capillipes* | Chalky bluestem | X | | | | X | | |
| *A. virginicus* | Broom-sedge | X | | | | | X | X |
| *Ardisia escallonioides* | Marlbery | | | | X | | | |
| *Arisaema triphyllum* | Jack-in-the-pulpit | | | | X | | | |
| *Aristida stricta* | Wiregrass | X | X | | | | | |
| *Asclepias perennis* | Milkweed | | | | X | | | |
| *Bacopa caroliniana* | Watermint | | | | | X | | |
| *Blechnum serrulatum* | Toothed mid-sorus fern | | | | X | | | |
| *Bidens laevis* | Beggar tick | X | | | | | | X |
| *B. pilosa* | Spanish-needles | | | | | | | X |
| *Boehmeria cylindrica* | False nettle | | | | X | | | |
| *Buchnera floridana* | Blueheart | | | | | | X | |
| *Callicarpa americana* | American beautyberry | X | | X | | | | |

TABLE II-2 (Continued)

| Species | Common Name | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture | Ruderal |
|---|---|---|---|---|---|---|---|---|
| Campsis radicans | Trumpet creeper | | | | X | | | |
| Cenchrus pauciflorus | Sandspur | X | | | | | X | X |
| Centella asiatica | Coinwort | | | X | X | X | X | X |
| Centrosema virginianum | Butterfly pea | | | | | | | X |
| Chapmannia floridana | Alicia | | X | | | | | |
| Chenopodium album | Pigweed | | | X | X | | | |
| Chrysobalanus oblongifolia | Gopher apple | | X | | | | | |
| Cladium jamaicense | Sawgrass | | | | | X | | |
| Clematis reticulata | Clematis | | | X | | | | |
| Commelina erecta | Dayflower | | X | | | | | |
| Commelina sp. | Dayflower | X | | X | | | | X |
| Coreopsis leavenworthii | Tickseed | | | | | | X | X |
| Cuphea carthagenensis | Waxweed | | | | | X | | X |
| Cynodon dactylon | Bermuda grass | | | | | | X | X |
| Cyperus brevifolius | Sedge | X | | | | | | |
| C. globulosus | Sedge | | | | | X | | |
| C. haspan | Sedge | | | | | X | | |
| C. polystachyos | Sedge | | | | | X | | |
| C. retrorsus | Sedge | X | | | | | | |
| Desmodium paniculatum | Beggar's lice | X | | X | | X | | |
| Dichromena colorata | Star rush | X | | X | | | | |
| Digitaria adscendens | Crabgrass | | X | | | | X | |
| Diodia virginiana | Buttonwood | | | | | X | | |
| Diospyros virginiana | Persimmon | X | X | X | | | X | X |
| Dryopteris ludoviciana | Southern shield fern | | | | X | | | |
| Eclipta alba | Yerba-de-tago | | | | | X | | |
| Egeria densa | Brazilian elodea | | | | | | | X |
| Eichhornia crassipes | Water hyacinth | | | | | | | X |
| Eleocharis acicularis | Spikerush | | | | | X | | |
| E. baldwinii | Spikerush | X | | | | | | |
| Elephantopus elatus | Elephants-foot | X | | | | | X | X |
| E. tomentosus | Elephants-foot | X | | | | | | |
| Erechtites hieracifolia | Fireweed | | | | | X | | X |
| Erianthus giganteus | Plumegrass | X | | | | | | |
| Erigeron canadensis | Horse-weed | | | | | | X | X |
| Eupatorium capillifolium | Dog fennel | X | | X | | X | X | |
| E. coelestinum | Mistflower | | | | X | | | |
| E. compositifolium | Dog fennel | | | | | | | X |
| Euphorbia sp. | Spurge | | X | | | | | |
| Fimbristylis puberula | Sedge | X | | | | | | |
| Galactia elliottii | Milk pea | X | | | | | X | |
| Galium obtusum | Bedstraw | | | | X | X | | |
| G. tinctorium | Bedstraw | X | | | | X | | |
| Gelsemium sempervirens | Yellow jessamine | X | X | | | | | |
| Glottidium vesicarium | Bladder pod | | | | | X | | |

TABLE II-2 (Continued)

Page 4 of 6

| Species | Common Name | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture | Ruderal |
|---|---|---|---|---|---|---|---|---|
| Helianthus sp. | Sunflower | X | | | | | | |
| Hydrocotyle umbellata | Pennywort | | | | X | X | X | X |
| Hypericum fasciculatum | St. Johns wort | | | | | X | | |
| Hydrolea corymbosum | Sky-flower | | | | | X | | |
| H. nitidum | St. Johns wort | | | | | X | | |
| Iris hexagona | Blue flag | | | | | X | | |
| Itea virginica | Sweet-spires | | | | X | | | |
| Juncus effusus | Soft rush | | | | | X | | X |
| Lemna minor | Duckweed | | | | X | X | | |
| Limnobium spongia | Frog's-bit | | | | X | X | | |
| Lindernia grandiflora | False pimpernel | | | | | X | | |
| Lippia nodiflora | Creeping charlie | | | X | | X | X | X |
| Liquidambar styraciflua | Sweetgum | | | X | X | | | |
| Liatris sp. | Blazing-star | X | | | | | | |
| Loinserina areolata | Netted chain fern | | | | X | | | |
| Ludwigia palustris | Marsh purslane | | | | X | X | | X |
| Lyonia ferruginea | Staggerbush | X | | | | | | |
| Magnolia virginiana | Sweetbay | | | | X | | | |
| Micranthemum umbrosum | Baby's tears | | | | | X | | X |
| Morus rubra | Red mulberry | | | | X | | | |
| Myrica cerifera | Wax myrtle | X | | X | X | | | X |
| Nephrolepis exaltata | Boston fern | | | | X | | | |
| Nuphar advena | Spatterdock | | | | | X | | |
| Nymphoides aquatica | Floating heart | | | | | X | | |
| Opuntia sp. | Prickly-pear | | X | | | | | |
| Oplismenus setarius | Grass | | | X | | | | |
| Orontium aquaticum | Golden-club | | | | X | | | |
| Osmunda cinnamomea | Cinnamon fern | | | | X | X | | |
| O. regalis | Royal fern | | | | X | | | |
| Oxalis corniculata | Wood sorrel | | | X | | | X | X |
| Panicum hemitomon | Maidencane | | | | | X | | |
| P. portoricense | Panicum | | | | | X | | |
| P. virgatum | Panicum | | | | X | | | |
| Parthenocissus quinquefolia | Virginia creeper | X | | X | | | | |
| Paspalum conjugatum | Paspalum | | | | X | | | X |
| P. dissectum | Water paspalum | | | | | X | | |
| P. notatum | Bahia grass | X | | X | | | X | X |
| P. setaceum | Paspalum | | X | | | | | |
| Peltandra virginica | Spoon-flower | | | | X | | | |
| P. sagittifolia | Spoon-flower | | | | X | | | |
| Penstemon sp. | Penstemon | | | X | | | | |
| Phytolacca americana | Pokeweed | X | X | X | | | X | X |
| Pistia stratriotes | Watter-lettuce | | | | X | | | |
| Pluchea foetida | Stinking fleabane | | | | | X | | |
| P. rosea | Marsh fleabane | | | | | X | | |

TABLE 11-2 (Continued) Page 5 of 6

| Species | Common Name | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture | Ruderal |
|---|---|---|---|---|---|---|---|---|
| Polygala nana | Bachelor's button | X | | | | | | |
| P. rugelii | Yellow milkwort | | | | | X | | |
| Polygonum hydropiperoides | Smartweed | | | | | X | | X |
| Polygonum punctatum | Smartweed | | | | X | X | X | X |
| Pontederia cordata | Pickerelweed | | | | | X | | |
| Portulaca pilosa | Pink purslane | | | X | | | | |
| Psilocarya nitens | Baldrush | | | | | X | | |
| Pteridium aquilinum | Bracken fern | X | | | | | | |
| Pterocaulon undulatum | Rabbit tobacco | X | X | X | | | X | |
| Rhus radicans | Poison ivy | | | X | X | | | |
| Rhynchospora corniculata | Beakrush | | | | | X | | |
| R. miliacea | Beakrush | | | | X | | | |
| R. tracyi | Beakrush | | | | | X | | |
| Rubus spp. | Blackberry | X | | X | X | | | X |
| Sabal minor | Bluestem palmetto | | | | | X | | |
| Sagittaria graminea | Arrowhead | | | | | X | | |
| S. lancifolia | Arrowhead | | | | | X | | |
| Samolus parviflorus | Water pimpernel | | | | | | | X |
| Saururus cernuus | Lizard's tail | | | | X | | | |
| Serenoa repens | Saw palmetto | X | X | X | X | | X | |
| Setaria geniculata | Foxtail | X | | | | | X | X |
| Smilax spp. | Greenbriar | X | | X | X | | | X |
| Solanum aculeatissimum | Soda apple | X | | X | X | | | |
| Solidago microcephala | Goldenrod | X | | | | | | |
| Solidago sp. | Goldenrod | | X | | | | | |
| Spartina bakerii | Sand cordgrass | | | | | X | | X |
| Spiranthes cernua | Ladies' tresses | | | | | | X | |
| Sporobolus poiretii | Smutgrass | X | | | | | X | X |
| Stillingia sylvatica | Queen's delight | X | | | | | | |
| Teucrium canadense | Wood sage | | | | | | | X |
| Thalia geniculata | Arrowroot | | | | | X | | |
| Thelypteris normalis | Widespread maiden fern | | | | X | | | |
| Tripogandra rosea | Roseling | | X | | | | | |
| Typha latifolia | Cattail | | | | | X | | |
| Ulmus americana | American elm | | | | X | | | |
| Urena lobata | Caesar weed | X | | X | | | | X |
| Utricularia purpurea | Bladderwort | | | | | X | | |
| Vitis rotundifolia | Muscadine grape | | | X | X | | | |
| Wolffia sp. | Water-meal | | | | | X | | |
| Wolffiella floridana | Bogmat | | | | | X | | |
| Woodwardia virginica | Virginia chain fern | | | | X | | | |
| Ximenia americana | Tallowwood | X | | X | X | | | |
| Zephranthes treatiae | Zephyr lily | | | X | | | | |

TABLE II-2 (Continued)

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| Species | Common Name | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture | Ruderal |
|---|---|---|---|---|---|---|---|---|
| Epiphytic Orchids, Ferns, and Bromeliads | | | | | | | | |
| *Campyloneurum phyllitidis* | Broad strap-fern | | | | X | | | |
| *Encyclia tampensis* | Butterfly orchid | | | X | X | | | |
| *Polypodium polypodioides* | Resurrection fern | | X | X | X | | | |
| *Tillandsia recurvata* | Ball-moss | | | | X | | | |
| *T. setacea* | Needle-leaved wild pine | | X | X | X | | | |
| *T. usneoides* | Spanish moss | X | X | X | X | | | |

Source: CF Mining Corporation, 1976.
MCC, 1977, field observations.

TABLE II-3

VERTEBRATE SPECIES EXPECTED OR KNOWN TO OCCUR ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY

Page 1 of 8

| Common Name | Scientific Name | Seasonal[a] Species | Relative[a] Abundance | Species Observed Onsite | Usual On-Site Habitat(s)[b] Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
|---|---|---|---|---|---|---|---|---|---|---|
| Pouched Mammals: Marsupialia | | | | | | | | | | |
| Opossum | Didelphis marsupialis | | C | X | X | X | X | X | X | |
| Insect-eaters: Insectivora | | | | | | | | | | |
| Shorttail shrew | Blarina brevicauda | | C | | X | X | X | X | X | X |
| Least shrew | Cryptotis parva | | C | | X | X | X | X | X | X |
| Eastern mole | Scalopus aquaticus | | C | X | | X | X | X | X | X |
| Bats: Chiroptera | | | | | | | | | | |
| Big brown bat | Eptesicus fuscus | | R | | X | X | X | X | X | X |
| Eastern yellow bat | Lasiurus intermedius | | U | | X | X | X | X | X | X |
| Seminole bat | L. seminolus | | R | | X | X | X | X | X | X |
| Evening bat | Nycticeius humeralis | | C | | X | X | X | X | X | X |
| Eastern big-eared bat | Plecotus rafinesquei | | R | | X | X | X | X | X | X |
| Mexican freetail bat | Tadarida brasiliensis | | U | | X | X | X | X | X | X |
| Flesh-eaters. Carnivora | | | | | | | | | | |
| Florida black bear | Ursus americanus floridanus | | R | | | | | X | | |
| Raccoon | Procyon lotor | | C | X | | | X | X | X | |
| River otter | Lutra canadensis | | R | X | | | | | | |
| Florida weasel | Mustela frenata olivacea | | R | | X | X | X | X | X | |
| Striped skunk | Mephitis mephitis | | U | X | X | X | X | X | X | |
| Spotted skunk | Spilogale putorius | | R | | X | X | X | X | X | |
| Gray fox | Urocyon cinereoargenteus | | R | | X | X | X | X | X | |
| Florida panther | Felis concolor | | R | | | | X | X | | |
| Bobcat | Lynx rufus | | U | | X | X | X | X | X | |
| Gnawing Mammals: Rodentia | | | | | | | | | | |
| Southern flying squirrel | Glaucomys volans | | R | | | | X | X | | |
| Eastern gray squirrel | Sciurus carolinensis | | C | X | | X | X | X | | |
| Sherman's fox squirrel | S. niger shermani | | R | X | X | X | X | | | |
| Pocket gopher | Geomys pinetis | | C | X | | X | X | | | X |
| Eastern harvest mouse | Reithrodontomys humilis | | U | | | | | | X | X |
| Florida mouse | Peromyscus floridana | | R | | | X | | | | |
| Cotton mouse | P. gossypinus | | C | | | | | X | | X |
| Eastern woodrat | Neotoma floridana | | U | | | | X | X | | |
| Rice rat | Oryzomys palustris | | C | | | | | | X | |
| Hispid cotton rat | Sigmodon hispidus | | C | | X | | X | | X | X |
| Round-tailed muskrat | Neofiber alleni | | U | | | | | | X | |
| House mouse | Mus musculus | | C | | | | | | | X |
| Black rat | Rattus rattus | | C | X | X | | | | | X |

TABLE II-3 (Continued)

| Common Name | Scientific Name | Seasonal$^a$ Species | Relative$^a$ Abundance | Species Observed Onsite | Usual On-Site Habitat(s)$^b$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
| Rabbits: Leporidae | | | | | | | | | | |
| Eastern cottontail | *Sylvilagus floridanus* | | C | X | X | X | X | X | X | X |
| Marsh rabbit | *S. palustris* | | U | | | | X | X | X | |
| Even-toed Hoofed Mammals: | | | | | | | | | | |
| Artiodactyla | | | | | | | | | | |
| Wild hog | *Sus scrofa* | | C | X | X | | X | X | X | |
| Whitetail deer | *Odocoileus virginiana* | | R | X | X | | X | X | | |
| Domestic Cow | *Bos taurus* | | C | X | X | X | X | | | X |
| Odd-toed Mammals | | | | | | | | | | |
| Perissodactyla | | | | | | | | | | |
| Horse | *Equus caballus* | | C | X | | | | | | X |
| Armadillos: Xenanthra | | | | | | | | | | |
| Armadillo | *Dasypus novemcinctus* | | A | X | X | X | X | X | X | X |
| BIRDS | | | | | | | | | | |
| Grebes: Podicipediformes | | | | | | | | | | |
| Pied-billed grebe | *Podilymbus podiceps* | P | R | | | | | | | |
| Pelicans and Allies: Pelecaniformes | | | | | | | | | | |
| Anhinga | *Anhinga anhinga* | | U | X | | | | | | |
| Double-crested cormorant | *Phalacrocorax auritus* | P | C | | | | | | X | |
| Waterfowl: Anseriformes | | | | | | | | | | |
| Wood duck | *Aix sponsa* | | U | X | | | | X | | |
| Pintail | *Anas acuta* | W | U | | | | | | X | |
| American widgeon | *A. americana* | W | R | | | | | | X | |
| Green-winged teal | *A. crecca* | W | R | | | | | | X | |
| Blue-winged teal | *A. discors* | W | U | | | | | | X | |
| Mottled duck | *A. fulvigula* | P | C | X | | | | | X | |
| Mallard | *A. platyrhynchos* | W | U | X | | | | | X | |
| Black duck | *A. rubripes* | W | R | | | | | | X | |
| Gadwall | *A. strepera* | W | R | | | | | | X | |
| Northern shoveller | *A. clypeata* | W | R | | | | | | X | |
| Lesser scaup | *Aythya affinis* | W | C | | | | | | X | |
| Hooded merganser | *Lophodytes cucallatus* | W | R | | | | | X | X | |
| Red-breasted merganser | *Mergus serrator* | W | R | | | | | X | X | |
| Vultures, Hawks & Falcons: Falconiformes | | | | | | | | | | |
| Turkey vulture | *Cathartes aura* | P | A | X | X | X | X | X | X | X |
| Black vulture | *Coragyps atratus* | P | A | X | X | X | X | X | X | X |
| Swallow-tailed kite | *Elanoides forificatus* | S | U | | | | | X | X | |
| White-tailed kite | *Elanus caeruleus* | S | R | | X | X | X | X | X | X |
| Cooper's hawk | *Accipiter cooperii* | W | R | X | X | | X | X | X | |

TABLE 11-3 (Continued)

|  |  |  |  |  | Usual On-Site Habitat(s)[b] |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | Scientific Name | Seasonal[a] Species | Relative[a] Abundance | Species Observed Onsite | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
| Sharp-shinned hawk | A. striatus | W | R |  | X |  | X | X |  | X |
| Marsh hawk | Circus cyaneus | W | C | X | X |  |  |  | X | X |
| Short-tailed hawk | Buteo brachyurus | P | U |  | X | X | X |  |  |  |
| Florida red-tailed hawk | B. jamaicensis umbrinus | P | C | X | X | X | X | X | X | X |
| Red-shouldered hawk | B. lineatus alleni | P | C | X | X | X | X | X | X | X |
| Broad-winged hawk | B. platypterus | W | R |  | X | X | X | X | X | X |
| Audubon's caracara | Caracara cheriway | P | U |  | X | X | X | X | X | X |
| Merlin | Falco columbarius audubonii | W | U |  | X | X | X | X |  | X |
| Southeastern kestrel | F. sparverius paulus | P | R |  | X | X | X | X |  | X |
| Eastern kestrel | F. sparverius sparverius | W | A | X | X | X | X | X |  | X |
| Peregrine falcon | F. peregrinus | P | R |  | X |  |  |  | X | X |
| Southern bald eagle | Haliaeetus leucocephalus | W | R |  |  | X |  | X |  |  |
| Osprey | Pandion haliaetus | P | R |  |  |  |  | X |  |  |
| Gallinaceous Birds: Galliformes |  |  |  |  |  |  |  |  |  |  |
| Florida turkey | Meleagris gallopavo osceola | P | U | X | X |  | X | X |  |  |
| Florida bobwhite quail | Colinus virginianus floridanus | P | C | X | X |  | X |  |  | X |
| Herons and Allies: Ciconiiformes |  |  |  |  |  |  |  |  |  |  |
| Great egret | Casmerodius albus | P | C | X |  |  |  |  | X |  |
| Snowy egret | Egretta thula | P | C | X |  |  |  |  | X |  |
| Cattle egret | Bubulcus ibis | P | A | X | X |  | X |  |  | X |
| Great blue heron | Ardea herodias | P | C | X |  |  |  |  | X |  |
| Louisiana heron | Hydranassa tricolor | P | U | X |  |  |  |  | X |  |
| Little blue heron | Florida caerulea | P | C | X |  |  |  |  | X |  |
| Green heron | Butorides virescens | P | C | X |  |  |  |  | X |  |
| Black-crowned night heron | Nycticorax nycticorax | P | U | X |  |  |  | X | X |  |
| Yellow-crowned night heron | Nyctanassa violacea | P | R |  |  |  |  | X |  |  |
| American bittern | Botaurus lentiginosus | P | U |  |  |  |  |  | X |  |
| Least bittern | Ixobrychus exilis | P | U | X |  |  |  |  | X |  |
| Wood stork | Mycteria americana | P | U | X |  |  |  |  | X |  |
| Glossy ibis | Plegadis falcinellus | P | U | X |  |  |  |  | X |  |
| White ibis | Eudocimus albus | P | U | X |  |  |  |  | X |  |
| Cranes and Allies: Gruiformes |  |  |  |  |  |  |  |  |  |  |
| Florida sandhill crane | Grus canadensis pratensis | P | U | X | X |  |  |  | X | X |
| Limpkin | Aramus guarauna | P | U |  |  |  |  | X | X |  |
| Sora | Porzana carolina | W | U |  |  |  |  |  | X |  |
| Yellow rail | Coturnicops noveboracensis | W | R |  |  |  |  |  | X |  |
| Black rail | Laterallus jamaicensis | S | R |  |  |  |  |  | X |  |
| King rail | Rallus elegans | P | U | X |  |  |  |  |  | X |
| Virginia rail | R. limicola | W | R |  |  |  |  |  | X |  |
| Common gallinule | Gallinula chloropus | P | U |  |  |  |  |  |  | X |
| Purple gallinule | Porphyrula martinica | P | U |  |  |  |  |  |  | X |
| American coot | Fulica americana | W | U |  |  |  |  |  |  | X |

TABLE II-3 (Continued)

| Common Name | Scientific Name | Seasonal[a] Species | Relative[a] Abundance | Species Observed Onsite | Usual On-Site Habitat(s)[b] |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
| **Shôrebirds, Gulls, and Alcids:** |  |  |  |  |  |  |  |  |  |  |
| Charadriiformes |  |  |  |  |  |  |  |  |  |  |
| Black-necked stilt | Himantopus mexicanus | S | R |  |  |  |  |  |  |  |
| Killdeer | Charadrius vociferus | P | A | X | X |  |  |  |  | X |
| Spotted sandpiper | Actitis macularia | T | U | X |  |  |  |  |  | X |
| Greater yellowlegs | Tringa melanoeucus | W | C |  |  |  |  |  |  | X |
| Lesser yellowlegs | T. flavipesi | W | C |  |  |  |  |  |  | X |
| Solitary sandpiper | T. solitaria | T | R |  |  |  |  |  |  | X |
| Short-billed dowitcher | Limnodromus griseus | T | R |  |  |  |  |  |  | X |
| Long-billed dowitcher | L. scolopaceus | T | R |  |  |  |  |  |  | X |
| Pectoral sandpiper | Calidris melanotos | T | R |  |  |  |  |  |  | X |
| Least sandpiper | C. minutilla | W | U |  |  |  |  |  |  | X |
| American woodcock | Philohela minor | W | R | X |  |  |  |  |  | X |
| Common snipe | Capella gallinago | W | U |  |  |  |  |  | X | X |
| **Pigeons and Doves: Columbiformes** |  |  |  |  |  |  |  |  |  |  |
| Mourning dove | Zenaida macroura | P | A | X | X | X | X |  |  | X |
| Ground dove | Columbigallina passerina | P | C | X | X |  | X |  |  | X |
| Rock dove | Columba livia | P | C |  |  |  |  |  |  | X |
| **Cuckoos: Cuculiformes** |  |  |  |  |  |  |  |  |  |  |
| Yellow-billed cuckoo | Coccyzus americanus | S | U | X |  | X | X | X |  |  |
| Black-billed cuckoo | C. erythropthalmus | T | R |  |  | X | X | X |  |  |
| **Owls: Strigiformes** |  |  |  |  |  |  |  |  |  |  |
| Screech owl | Otus asio | P | U |  | X | X | X | X | X | X |
| Great horned owl | Bubo virginianus | P | U |  | X | X | X | X | X | X |
| Short-eared owl | Asio flammeus | W | R |  | X | X | X | X | X | X |
| Barn owl | Tyto alba | P | U |  | X |  |  |  | X | X |
| Barred owl | Strix varia | P | U | X | X | X | X | X | X | X |
| Florida burrowing owl | Speotyto cunicularia floridana | P | C | X | X |  |  |  | X | X |
| **Goatsuckers: Caprimulgiformes** |  |  |  |  |  |  |  |  |  |  |
| Chuck-wills-widow | Caprimulgus carolinensis | S | U | X | X | X | X | X | X | X |
| Whip-poor-will | C. vociferus | W | R |  | X | X | X | X | X | X |
| Eastern nighthawk | Chordeiles minor minor | T | U |  | X | X | X | X | X | X |
| Florida nighthawk | C. minor chapmanii | S | C | X | X | X | X | X | X | X |
| **Swifts and Hummingbirds: Apodiformes** |  |  |  |  |  |  |  |  |  |  |
| Chimney swift | Chaetura pelagica | S | U | X | X |  |  |  | X | X |
| Ruby-throated hummingbird | Archilochus colubris | S | R |  |  |  | X | X |  |  |
| **Kingfishers: Coraciiformes** |  |  |  |  |  |  |  |  |  |  |
| Belted kingfisher | Megaceryle alcyon | W | C | X |  |  |  |  | X |  |

TABLE II-3 (Continued)

| Common Name | Scientific Name | Seasonal[a] Species | Relative[a] Abundance | Species Observed Onsite | Usual On-Site Habitat(s)[b] Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
|---|---|---|---|---|---|---|---|---|---|---|
| Woodpeckers: Piciformes | | | | | | | | | | |
| Common flicker | Colaptes auratus | P | U | X | X | X | X | | | |
| Pileated woodpecker | Dryocopus pileatus | P | U | X | | X | X | X | | |
| Red-bellied woodpecker | Centurus carolinus | P | C | X | X | X | X | X | | |
| Red-headed woodpecker | Melanerpes erythrocephalus | P | U | X | | X | X | X | | |
| Yellow-bellied sapsucker | Sphyrapicus varius | W | U | | | | X | X | | |
| Red-cockaded woodpecker | Dendrocopos borealis | P | R | | X | | | | | |
| Downy woodpecker | D. pubescens | P | U | | | X | X | X | | |
| Hairy woodpecker | D. villosus | P | R | | | | X | X | | |
| Perching Birds: Passeriformes | | | | | | | | | | |
| Eastern kingbird | Tyrannus tyrannus | S | U | X | X | X | X | X | | X |
| Western kingbird | T. verticalis | W | R | X | | | | | | X |
| Southern crested flycatcher | Myiarchus crinitus crinitus | S | U | X | X | X | X | X | | |
| Scissor-tailed flycatcher | Muscivora forfic | P | R | X | | | | | | X |
| Acadian flycatcher | Epidonax virescens | S | R | X | X | | | | | |
| Eastern phoebe | Sayornis phoebe | W | U | X | X | X | X | X | | |
| Eastern wood peewee | Contopus virens | T | U | | X | X | X | X | | |
| Barn swallow | Hirundo rustica | T | U | | X | | | | X | X |
| Tree swallow | Iridoprocne bicolor | W | A | | X | | | | X | X |
| Bank swallow | Riparia riparia | T | R | | X | | | | X | X |
| Rough-winged swallow | Stelgidopteryx ruficollis | T | R | X | X | | | | X | X |
| Purple martin | Progne subis | S | U | | X | | | | X | X |
| Blue jay | Cyanocitta cristata | P | A | X | X | X | X | X | | X |
| Scrub jay | Aphelocoma coerulescens | P | R | X | | X | | | | |
| Florida crow | Corvus brachyrhynchos pascuus | P | C | X | X | X | X | | | X |
| Fish crow | C. ossifragus | P | C | X | | | | X | X | X |
| Tufted titmouse | Parus bicolor | P | U | X | | | X | X | | |
| Brown-headed nuthatch | Sitta pusilla | P | C | X | X | X | | | | |
| Gray-headed nuthatch | S. pusilla caniceps | P | R | | X | X | | | | |
| Carolina chickadee | Parus carolinensis | P | C | X | X | X | | | | |
| Short-billed marsh wren | Cistothorus platynsis | W | R | | | | X | | | |
| House wren | Troglodytes aedon | W | U | | | | X | X | | |
| Carolina wren | Thryothorus ludovicianus | P | U | X | | | X | X | X | |
| Long-billed marsh wren | Telmatodytes palustris | W | U | X | | | | | X | |
| Eastern mockingbird | Mimus polyglottos polyglottos | P | A | X | X | X | X | X | | X |
| Gray catbird | Dumetella carolinensis | P | U | X | | | X | X | | |
| Brown thrasher | Toxostoma rufum | W | R | X | X | X | X | | | X |
| Eastern robin | Turdus migratorius migratorius | W | C | X | | X | X | X | | X |
| Hermit thrush | Catharus guttata | W | U | | X | X | X | X | | |
| Eastern olive-backed thrush | C. ustulata swainsoni | T | R | | X | X | X | X | | |
| Wood thrush | Hylocichla mustelina | S | C | X | X | | | | | |
| Veery | H. fuscens | S | R | X | X | X | | | | |
| Starling | Sturnus vulgaris | P | C | | | | | | | X |
| Florida bluebird | Sialia sialis grata | P | C | X | X | X | X | X | | |
| Blue-gray gnatcatcher | Polioptila caerulea | W | C | X | X | | X | X | | |
| Ruby-crowned kinglet | Regulus calendula | W | R | | X | | X | | | |
| American pipit | Anthus spinoletta | W | R | | X | | | | X | X |

TABLE II-3 (Continued)

Page 6 of 8

| Common Name | Scientific Name | Seasonal[a] Species | Relative[a] Abundance | Species Observed Onsite | Usual On-Site Habitat(s)[b] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
| Cedar waxwing | *Bombycilla cedrorum* | W | U | | | | X | X | | |
| Loggerhead shrike | *Lanius ludovicianus* | P | A | X | X | X | X | X | | X |
| White-eyed vireo | *Vireo griseus* | PZ | U | X | | | | X | | |
| Red-eyed vireo | *V. olivaceus* | S | U | X | X | X | X | X | | |
| Solitary vireo | *V. solitarius* | W | R | | | | | X | | |
| Yellow-throated vireo | *Vireo flavifrons* | T | U | | X | X | | | | |
| Hooded warbler | *Wilsonia citrina* | T | C | | X | X | | | | |
| Black-and-white warbler | *Mniotilta varia* | W | U | X | | | | X | | |
| Prothonotary warbler | *Protonotaria citrea* | S | R | | | | | X | | |
| Orange-crowned warbler | *Vermivora celata* | W | R | | | | | X | | |
| Northern parula | *Parula americana* | T | U | X | | | | X | | |
| Eastern yellow warbler | *Dendroica petechia aestiva* | T | R | | | | | X | | |
| Black-throated blue warbler | *D. caerulescens* | T | R | | | | | X | | |
| Yellow-rumped warbler | *D. coronata* | W | C | X | | | X | X | | |
| Prairie warbler | *D. discolor* | P | R | | | | | X | | |
| Yellow-throated warbler | *D. dominica* | W | R | | | | | X | | |
| Palm warbler | *D. palmarum* | W | C | X | X | X | X | X | | |
| Florida pine warbler | *D. pinus florida* | P | U | X | X | | X | X | | |
| Blackpoll warbler | *D. striata* | T | R | | | | | X | | |
| Cape May warbler | *D. tigrina* | T | R | X | X | | | | | |
| Black-throated green warbler | *D. virens* | T | R | | | | | X | | |
| Ovenbird | *Seiurus aurocapillus* | T | R | | | | | X | | |
| Northern waterthrush | *S. noveboracensis* | T | U | | | | | X | | |
| Louisiana waterthrush | *S. motacilla* | T | U | | | | | X | | |
| Common yellowthroat | *Geothlypis trichas* | P | U | X | X | | X | X | X | X |
| American redstart | *Setophaga ruticilla* | T | R | | | | | X | | |
| Bobolink | *Dolichonyx oryzivorus* | T | U | | X | | | | X | X |
| Eastern meadowlark | *Sturnella magna* | P | A | X | X | | | | X | X |
| Red-winged blackbird | *Agelaius phoeniceus* | P | A | X | | | | X | X | |
| Rusty blackbird | *Euphagus carolinus* | W | U | | | | | X | | |
| Boat-tailed grackle | *Cassidix major* | P | C | X | | | | X | X | |
| Common grackle | *Quiscalus quiscula* | P | C | X | | | | X | X | |
| Scarlet tanager | *Piranga olivacea* | T | R | | X | | X | | | |
| Summer tanager | *P. rubra* | T | R | | X | | X | | | |
| Cardinal | *Cardinalis cardinalis* | P | C | X | X | X | X | X | | X |
| Painted bunting | *Passerina ciris* | T | R | | X | X | X | X | | |
| Indigo bunting | *P. cyanea* | T | R | | X | X | X | X | | |
| American goldfinch | *Spinus tristis* | W | R | | X | | X | X | | X |
| Rufous-sided towhee | *Pipilo erythrophthalmus* | P | C | X | X | | X | | | |
| House sparrow | *Passer domesticus* | P | C | | | | | | | X |
| Northern oriole | *Icterus galbula* | T | R | | X | | | | | |
| Orchard oriole | *I. spurius* | T | U | | X | | | | | |
| Brown-headed cowbird | *Molothrus ater* | P | C | | | | | | X | X |
| Rose-breasted grosbeak | *Pheucticus ludovicianus* | T | R | X | | X | X | | | |
| Blue grosbeak | *Guiraca caerulea* | W | C | X | | X | | | | X |
| Savannah sparrow | *Passerculus sandwichensis* | W | U | | | | | | | X |
| Grasshopper sparrow | *Ammodramus savannarum* | W | U | | | | | | | X |
| Le Conte's sparrow | *Passerherbulus caudacutus* | W | U | | | | | | X | X |
| Vesper sparrow | *Pooecetes gramineus* | W | U | | X. | | | | | X |
| Chipping sparrow | *Spizella passerina* | W | U | | X | | | | | X |

TABLE II-3 (Continued)

| Common Name | Scientific Name | Seasonal$^a$ Species | Relative$^a$ Abundance | Species Observed Onsite | Usual On-Site Habitat(s)$^b$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
| Field sparrow | S. pusilla | W | R | X | X | | | | | X |
| Swamp sparrow | Melospiza georgiana | W | U | | | | | | X | |
| Song sparrow | M. melodia | W | V | | X | | | | | X |
| Bachman's sparrow | Aimophila aestivalis | P | U | | X | | | | | |
| REPTILES AND AMPHIBIANS | | | | | | | | | | |
| Crocodilians: Crocodylidae | | | | | | | | | | |
| American alligator | Alligator mississippiensis | | U | X | | | | | X | |
| Turtles: Testudines | | | | | | | | | | |
| Florida snapping turtle | Chelydra serpentina psceola | | R | X | | | | | X | |
| Stinkpot | Sternothaerus odoratus | | C | | | | | | X | |
| Striped mud turtle | Kinosternon bauri | | U | | | | | | X | |
| Florida mud turtle | K. subrubrum steindachneri | | U | X | | | | | X | |
| Florida box turtle | Terrapene carolina bauri | | U | X | X | X | X | X | X | X |
| Peninsula cooter | Pseudemys floridana peninsularis | | C | X | | | | X | X | |
| Florida red-bellied turtle | P. nelsoni | | U | | | | | X | | |
| Florida chicken turtle | Deirochelys reticularia chrysea | | C | X | | | | X | X | |
| Gopher tortoise | Gopherus polyphemus | | C | X | X | X | X | | | X |
| Florida softshell | Trionyx ferox | | U | | | | | X | X | |
| Lizards: Lacertilia | | | | | | | | | | |
| Green anole | Anolis carolinensis | | C | | | | X | X | | |
| Six-lined racerunner | Cnemidophorus sexlineatus | | C | | X | X | X | X | | X |
| Ground skink | Lygosoma laterale | | C | | X | | X | X | | |
| Brown red-tailed skink | Eumeces egregius onocrepis | | R | | | X | X | | | |
| Southeastern five-linked skink | E. inexpectatus | | C | X | X | X | X | | | |
| Broad-headed skink | E. laticeps | | R | X | | | X | | X | X |
| Florida sand skink | Neoseps reynoldsi | | R | | | X | X | | | |
| Eastern slender glass lizard | Ophisaurus attenuatus longicaudis | | R | | X | X | X | | | X |
| Island glass lizard | O. compressus | | R | | X | | | | | |
| Eastern glass lizard | O. ventralis | | U | | X | | X | | X | X |
| Southern fence lizard | Sceloporus undulatus undulatus | | U | X | X | X | X | | | X |
| Amphisbaenians: Amphisbaenia | | | | | | | | | | |
| Worm lizard | Rhineura floridana | | R | | X | X | X | | | X |
| Snakes: Serpentes | | | | | | | | | | |
| Florida green water snake | Natrix cyclopion floridana | | R | | | | | X | X | |
| Florida water snake | N. sipedon pictiventris | | C | X | | | | X | X | |
| Brown water snake | N. taxispilota | | R | X | | | | X | X | |
| South Florida swamp snake | Seminatrix pygaea cyclas | | U | | | | | X | X | |
| Florida brown snake | Storeria dekayi victa | | U | X | X | | X | X | X | |
| Southern ribbon snake | Thamnophis sauritus sackeni | | U | X | | | | X | X | |
| Eastern garter snake | T. sirtalis sirtalis | | U | X | X | X | X | X | X | X |

TABLE II-3 (Continued)

| Common Name | Scientific Name | Seasonal[a] Species | Relative[a] Abundance | Species Observed Onsite | Usual On-Site Habitat(s)[b] |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | Palmetto Range | Xeric Hammock | Mesic Hammock | Hardwood Swamp | Fresh Marsh | Pasture |
| Striped swamp snake | Liodytes alleni |  | R |  |  |  |  | X | X |  |
| Eastern hognose snake | Heterodon platyrhinos |  | R |  | X | X | X |  |  | X |
| Southern hognose snake | H. simus |  | R |  | X | X | X |  |  | X |
| Yellow-lipped snake | Rhadinaea flavilata |  | R |  | X |  |  | X | X |  |
| Southern ringneck snake | Diadophis punctatus punctatus |  | U |  |  |  | X | X | X | X |
| Eastern mud snake | Farancia abacura abacura |  | U |  |  |  |  | X | X |  |
| Southern black racer | Coluber constrictor priapus |  | C | X | X | X | X | X | X | X |
| Eastern coachwhip | Masticophis flagellum flagellum |  | U |  | X | X | X |  |  | X |
| Rough green snake | Opheodrys aestivus |  | U |  |  |  | X | X | X |  |
| Eastern indigo snake | Drymarchon corais couperi |  | U | X | X | X | X |  |  | X |
| Corn snake | Elaphe guttata guttata |  | U |  | X | X | X | X | X | X |
| Yellow rat snake | E. obsoleta quadrivittata |  | U | X | X | X | X | X | X | X |
| Florida pine snake | Pituophis melanoleucus mugitus |  | U |  | X | X | X |  |  | X |
| Scarlet kingsnake | Lampropeltis doliata doliata |  | R |  | X | X | X |  |  |  |
| Florida kingsnake | L. getulus floridana |  | U |  | X | X | X |  |  | X |
| Scarlet snake | Cemophora coccinea |  | R |  |  | X | X |  |  |  |
| Florida crowned snake | Tantilla coronata wagneri |  | R |  | X | X | X | X | X | X |
| Eastern coral snake | Micrurus fulvius |  | R |  | X | X | X | X | X | X |
| Eastern cottonmouth water moccasin | Agkistrodon piscivorus piscivorus |  | U |  |  |  |  | X | X |  |
| Dusky pigmy rattlesnake | Sistrurus miliarius barbouri |  | R |  | X |  | X | X | X |  |
| Eastern diamondback rattlesnake | Crotalus adamanteus |  | U | X | X | X | X |  |  | X |
| Salamanders: |  |  |  |  |  |  |  |  |  |  |
| Lesser siren | Siren intermedia |  | U |  |  |  |  |  | X |  |
| Greater siren | S. lacertina |  | C | X |  |  |  | X | X |  |
| Narrow-striped dwarf siren | Pseudobranchus striatus axanthus |  | R |  |  |  |  | X | X |  |
| Two-toed amphiuma | Amphiuma means means |  | R |  |  |  |  | X | X |  |
| Peninsula newt | Notophthalmus viridescens piaropicola |  | C | X |  |  |  | X | X |  |
| Slimy salamander | Plethodon glutinosus glutinosus |  | U |  |  |  | X | X | X |  |
| Dwarf salamander | Manculus quadridigitatus |  | R | X |  |  |  | X | X |  |
| Toads and Frogs: |  |  |  |  |  |  |  |  |  |  |
| Eastern spadefoot | Scaphiopus holbrooki |  | U |  | X | X | X |  |  |  |
| Greenhouse frog | Eleutherodactylus ricordi planirostris |  | U |  | X |  | X | X | X | X |
| Oak toad | Bufo quercicus |  | C |  | X | X | X | X | X | X |
| Southern toad | B. terrestris |  | U |  |  | X | X | X | X | X |
| Florida cricket frog | Acris gryllus dorsalis |  | C | X |  |  |  | X | X |  |
| Green treefrog | Hyla cinerea |  | C | X |  |  |  | X | X |  |
| Pinewoods treefrog | H. femoralis |  | U |  | X |  |  | X | X |  |
| Barking treefrog | H. gratiosa |  | U |  | X | X | X | X | X | X |
| Squirrel treefrog | H. squirella |  | A | X |  |  | X | X | X |  |
| Little grass frog | Limnaoedus ocularis |  | C |  |  |  |  | X | X | X |
| Florida chorus frog | Pseudacris nigrita verrucosa |  | C |  | X |  |  | X | X | X |
| Ornate chorus frog | Pseudacris ornata |  | U |  |  |  |  | X | X | X |
| Eastern narrow-mouthed toad | Gastrophryne carolinensis |  | C | X | X | X | X | X | X | X |
| Florida gopher frog | Rana aerolata aesopus |  | R |  | X | X | X |  |  | X |
| Bullfrog | R. catesbeiana |  | U | X |  |  |  | X | X |  |
| Pig frog | R. grylio |  | C | X |  |  |  | X | X |  |
| Southern leopard frog | R. pipiens sphenocephala |  | C | X |  |  |  | X | X |  |

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[a] Seasonal Species: W=Winter; S=Summer; T=Transient; P=Permanent
Relative Abundance: C=Common; R=Rare; U=Uncommon; A=Abundant

[b] Based on known habitat requirements.

## TABLE II-4

## SWAMP FOREST OVERSTORY IN SECTION 29 - 10 QUADRATS

| Species | Basal Area (in$^2$) | Basal Area (cm$^2$) | Frequency | Relative Density (Percent) | Relative Frequency (Percent) | Relative Dominance (Percent) | Importance Value (Cumulative Percent) |
|---|---|---|---|---|---|---|---|
| *Quercus hemisphaerica*<br>Laurel oak | 102 | 658 | 0.5 | 22.5 | 19.2 | 24.2 | 65.9 |
| *Acer rubrum*<br>Red maple | 32 | 206 | 0.4 | 10.0 | 15.4 | 3.4 | 28.8 |
| *Liquidambar styraciflua*<br>Sweetgum | 129 | 832 | 0.4 | 27.5 | 23.1 | 37.5 | 88.1 |
| *Ulmus americana*<br>American elm | 125 | 806 | 0.4 | 10.0 | 15.4 | 13.2 | 38.6 |
| *Pinus elliottii*<br>Slash pine | 80 | 516 | 0.1 | 2.5 | 3.8 | 2.1 | 8.4 |
| *Nyssa sylvatica* var. *biflora*<br>Blackgum | 75 | 484 | 0.4 | 22.5 | 15.4 | 17.8 | 55.7 |
| *Quercus nigra*<br>Water oak | 39 | 252 | 0.1 | 2.5 | 3.8 | 1.0 | 7.3 |
| *Magnolia virginiana*<br>Sweetbay | 29 | 187 | 0.1 | 2.5 | 3.8 | 0.8 | 7.1 |
| TOTAL |  |  |  | 100.0 | 99.9 | 100.0 | 299.9 |

Source: Dames & Moore field survey, 1980.

## TABLE II-5

## SWAMP FOREST OVERSTORY SECTION 16 - 10 QUADRATS

| Species | Basal Area (in$^2$) | Basal Area (cm$^2$) | Frequency | Relative Density (Percent) | Relative Frequency (Percent) | Relative Dominance (Percent) | Importance Value (cumulative Percent ) |
|---|---|---|---|---|---|---|---|
| Acer rubrum<br>Red maple | 845 | 5,540 | 0.8 | 35.0 | 33.3 | 17.4 | 85.7 |
| Quercus nigra<br>Water oak | 39 | 252 | 0.1 | 2.5 | 4.2 | 0.8 | 7.5 |
| Quercus hemisphaerica<br>Laurel oak | 59 | 381 | 0.2 | 5.0 | 8.3 | 1.2 | 14.5 |
| Salix caroliniana<br>Carolina Willow | 90 | 580 | 0.1 | 5.0 | 4.2 | 1.8 | 11.0 |
| Nyssa sylvatica var. biflora[a]<br>Blackgum | 3,317 | 21,394 | 0.6 | 27.5 | 25.0 | 68.0 | 120.5 |
| Magnolia virginiana<br>Sweetbay | 501 | 3,231 | 0.6 | 25.0 | 25.0 | 10.3 | 60.3 |
| TOTAL | | | | 100.0 | 100.0 | 99.5 | 299.5 |

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[a] High values due to large buttresses on trees.

Source: Dames & Moore field surveys, 1980.

## TABLE II-6

## SWAMP FOREST OVERSTORY IN SECTION 17 - 7 QUADRATS

| Species | Basal Area | | Frequency | Relative Density (Percent) | Relative Frequency (Percent) | Relative Dominance (Percent) | Importance Value (Cumulative Percent) |
|---|---|---|---|---|---|---|---|
| | ($in^2$) | ($cm^2$) | | | | | |
| Acer rubrum<br>Red maple | 867 | 5,592 | 0.57 | 25.0 | 21.2 | 29.0 | 75.2 |
| Ulmus americana<br>American elm | 1010 | 6,514 | 0.57 | 21.4 | 21.2 | 33.8 | 76.4 |
| Fraxinus pauciflora<br>Swamp ash | 462 | 2,980 | 0.57 | 21.4 | 21.2 | 15.4 | 58.0 |
| Magnolia virginiana<br>Sweetbay | 232 | 1,496 | 0.14 | 10.7 | 5.2 | 7.8 | 23.7 |
| Liquidambar styraciflua<br>Sweetgum | 100 | 645 | 0.28 | 7.1 | 10.4 | 3.3 | 20.8 |
| Nyssa sylvatica var. biflora<br>Blackgum | 29 | 187 | 0.14 | 3.6 | 5.2 | 4.5 | 13.3 |
| Quercus nigra<br>Water oak | 29 | 187 | 0.14 | 3.6 | 5.2 | 1.0 | 9.8 |
| Quercus hemisphaerica<br>Laurel oak | 157 | 1,012 | 0.28 | 7.1 | 10.4 | 5.2 | 22.7 |
| TOTAL | | | | 99.9 | 100.0 | 100.0 | 299.9 |

Source: Dames & Moore field surveys, 1980.

## TABLE II-7

## SWAMP FOREST OVERSTORY IN SECTION 22 - 5 QUADRATS

| Species | Basal Area | | Frequency | Relative Density (Percent) | Relative Frequency (Percent) | Relative Dominance (Percent) | Importance Value (Cumulative Percent) |
|---|---|---|---|---|---|---|---|
| | ($in^2$) | ($cm^2$) | | | | | |
| Pinus elliottii<br>Slash pine | 366 | 2,360 | 0.60 | 35.0 | 27.3 | 30.0 | 92.3 |
| Quercus hemisphaerica<br>Laurel oak | 80 | 516 | 0.40 | 10.0 | 18.2 | 6.7 | 34.9 |
| Acer rubrum<br>Red maple | 441 | 2,844 | 0.80 | 30.0 | 36.4 | 36.7 | 103.1 |
| Nyssa sylvatica var. biflora<br>Blackgum | 80 | 515 | 0.20 | 10.0 | 9.1 | 6.7 | 25.8 |
| Magnolia virginiana<br>Sweetbay | 235 | 1,516 | 0.20 | 15.0 | 9.1 | 19.5 | 43.6 |
| TOTAL | | | | 100.0 | 100.1 | 99.6 | 299.7 |

Source: Dames & Moore field surveys, 1980.

## TABLE II-8

## OVERSTORY IN SECTION 28 WEST - 10 QUADRATS

| Species | Basal Area | | Frequency | Relative Density (Percent) | Relative Frequency (Percent) | Relative Dominance (Percent) | Importance Value (Cumulative Percent) |
|---|---|---|---|---|---|---|---|
| | ($in^2$) | ($cm^2$) | | | | | |
| *Magnolia virginiana*<br>Sweetbay | 3244 | 20,924 | 0.9 | 62.5 | 42.9 | 62.6 | 168.0 |
| *Acer rubrum*<br>Red maple | 206 | 1,329 | 0.4 | 10.0 | 19.0 | 4.0 | 33.0 |
| *Sabal palmetto*<br>Cabbage palm | 39 | 252 | 0.1 | 2.5 | 4.8 | 0.8 | 8.1 |
| *Quercus hemisphaerica*<br>Laurel oak | 29 | 187 | 0.1 | 2.5 | 4.8 | 0.6 | 7.9 |
| *Nyssa sylvatica* var. *biflora*<br>Blackgum | 833 | 5,373 | 0.3 | 12.5 | 14.3 | 16.1 | 42.9 |
| *Pinus serotina*<br>Pond pine | 826 | 5,328 | 0.3 | 10.0 | 14.3 | 16.0 | 40.3 |
| TOTAL | | | | 100.0 | 100.1 | 100.1 | 300.2 |

Source: Dames & Moore field surveys, 1980.

## TABLE II-9

## AVERAGE IMPORTANCE VALUE FOR TREES IDENTIFIED IN HARDWOOD SWAMP TRANSECTS ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY

| Species | Importance Value (Cumulative Percent) |
|---|---|
| *Acer rubrum*<br>Red maple | 65.1 |
| *Magnolia virginiana*<br>Sweetbay | 60.3 |
| *Nyssa sylvatica* var. *biflora*<br>Blackgum | 51.6 |
| *Quercus hemisphaerica*<br>Laurel oak | 29.2 |
| *Ulmus americana*<br>American elm | 23.0 |
| *Liquidambar styraciflua*<br>Sweetgum | 21.8 |
| *Pinus elliottii*<br>Slash pine | 20.1 |
| *Fraxinus pauciflora*<br>Swamp ash | 11.6 |
| *Pinus serotina*<br>Pond pine | 8.0 |
| *Quercus nigra*<br>Water oak | 4.9 |
| *Salix caroliniana*<br>Carolina willow | 2.2 |
| *Sabal palmetto*<br>Cabbage palm | 1.6 |

Source: Dames & Moore field surveys, 1980.

## TABLE II-10

## ZONATION AND VEGETATION OF MARSH COMMUNITIES ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY

| Zone | Water Depth | Dominant Plants |  |  | Associated Plants |
|---|---|---|---|---|---|
|  |  | Emergent | Floating | Submerged |  |
| 1 | Saturated to Mesic | Wax myrtle<br>Buttonbush<br>Live oak<br>Water pennywort<br>Sedges | - | - | Creeping charlie<br>False pimpernel<br>Blue flag<br>Alligator weed<br>Baby's tears<br>Water paspalum<br>Marsh purslane |
| 2 | 0 - 10 cm | Soft rush<br>Sand cordgrass | - | - | Water pennywort<br>Arrowhead<br>False pimpernel<br>Water paspalum<br>Blue flag<br>Smartweed |
| 3 | 10 - 30 cm | Maidencane<br>Pickerelweed<br>Sand cordgrass | Duckweed<br>Water hyacinth | Spikerush | Soft rush<br>Arrowroot<br>Bogmat<br>Bladderwort<br>Arrowhead<br>Frog's bit<br>Water lettuce |
| 4 | 30 - 60 cm | Maidencane<br>Pickerelweed | Water hyacinth<br>Duckweed<br>Water lettuce<br>Bogmat | Bladderwort<br>Spikerush | Arrowroot<br>Arrowhead |

Source: Dames & Moore field surveys, 1980.

## TABLE II-11

## PERCENT COVER AND FREQUENCY OF PLANTS IN A MARSH IN SECTION 5 OF THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY[a]

| Species<br>Common Name | Percent Cover | Frequency (percent) |
|---|---|---|
| *Eleocharis acicularis*<br>Spikerush | 11.8 | 27.7 |
| *Hydrocotyle umbellata*<br>Water pennywort | 2.1 | 5.6 |
| *Lemna minor*<br>Duckweed | 10.4 | 66.7 |
| *Limnobium spongia*<br>Frog's bit | 4.2 | 11.1 |
| *Panicum hemitomon*<br>Maidencane | 17.8 | 55.6 |
| *Polygonum punctatum*<br>Smartweed | 2.9 | 22.2 |
| *Pontederia cordata*<br>Pickerelweed | 33.6 | 66.7 |
| *Sagittaria lancifolia*<br>Arrowhead | 5.7 | 16.7 |
| *Spartina bakerii*<br>Sand cordgrass | 6.1 | 11.1 |
| *Utricularia purpurea*<br>Bladderwort | 6.1 | 38.9 |
| *Wolffiella floridana*<br>Bogmat | 11.0 | 38.9 |

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[a] Values are averages from 18 quadrats which were 1 square meter in size.

Source: Dames & Moore field surveys, 1980.

TABLE II-12

WETLAND SYSTEMS ON MISSISSIPPI CHEMICAL CORPORATION PROPERTY

| System[a] | Habitat Acreage Total | Swamp | Marsh | Mesic Hammock | Contiguity[b] | Fish and Wildlife Value | Potential Presence of Protected Faunal Species[c] | Vegetation and Habitat Diversity | Relative Water Retention Capacity (Value to Floodplain) | Degree of Disturbance |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 169 | 3 | 66 | 100 | Connected | High | High (1 species observed) | High; swamp diverse, moderate habitat diversity. | High | Low |
| B | 174 | 64 | 84 | 26 | Contiguous (headwater) | High | Moderate | High; rich swamp forest, 3 to 4 well developed vertical strata. | Moderate (out of floodplain) | Low |
| C | 82 | 19 | 48 | 15 | Contiguous (headwater) | Moderate | High | High; swamp diverse, habitat diversity high, high zonation in marshes. | Moderate (out of floodplain) | Low |
| D | 328 | 73 | 129 | 126 | Contiguous | Very high | Very High (10 species observed) | High zonation in marsh, Habitats diverse, rich. | High | Low |
| E | 220 | 7 | 193 | 20 | Contiguous | High | High (3 species observed) | Moderate; high zonation in marsh, Habitat diversity low. | High | High near Oak Creek channel, low elsewhere. |

---

[a] See Figure II-7 for system location.
[b] See Figure II-8.
[c] Sites not surveyed equally.

Note: System is defined as an area encompassing wetlands integrated with adjacent mesic habitat.

Source: Dames & Moore, 1980.

## TABLE II-13

## PHYTOPLANKTON COLLECTED FROM THE MISSISSIPPI CHEMICAL CORPORATION SITE APRIL 1980

(Numbers are organisms/liter x $10^4$)

Page 1 of 2

| Taxa | Brushy Creek | | | Oak Creek | | |
|---|---|---|---|---|---|---|
| | B-1[a] | B-2 | B-3 | O-1 | O-2 | O-3 |
| Cyanophyta | 0.3 | 2.0 | 2.7 | 0.2 | -- | 18.5 |
| Cyanophyceae | | | | | | |
| *Anabaena* sp. | -- | 1.1 | 1.6 | -- | -- | 18.5 |
| *Calothrix* sp. | -- | 0.8 | 0.9 | 0.2 | -- | -- |
| *Closteridium* sp. | -- | -- | 0.2 | -- | -- | -- |
| *Spirulina* sp. | 0.3 | 0.1 | -- | -- | -- | -- |
| Chlorophyta | 7.8 | 20.0 | 6.1 | 7.7 | 6.2 | 96.9 |
| Clorophyceae | | | | | | |
| *Ankistrodesmus* sp. | -- | 2.2 | 0.2 | 0.3 | 0.1 | -- |
| *Characium* sp. | -- | -- | -- | -- | -- | 4.6 |
| *Chlamydomonas* sp. | -- | -- | 0.2 | 0.5 | -- | -- |
| *Chlorella* sp. | -- | -- | -- | 1.5 | 1.8 | 5.4 |
| *Chlorococcum* spp. | 2.4 | -- | 0.3 | -- | -- | -- |
| Chlorococcales | -- | -- | -- | -- | -- | 20.6 |
| *Closterium* sp. | 1.2 | 0.4 | 0.4 | -- | 0.1 | -- |
| *Cosmarium* sp. | 0.9 | 0.3 | -- | 0.2 | 0.8 | 2.3 |
| *Crucigenia* sp. | -- | -- | -- | 0.2 | -- | -- |
| *Mougeotia* sp. | -- | -- | -- | -- | -- | 0.2 |
| *Oedogonium* sp. | -- | 11.9 | 2.4 | -- | 0.4 | -- |
| *Oocystis* sp. | -- | -- | -- | -- | -- | 10.8 |
| *Palmodictyon* sp. | -- | -- | -- | 1.0 | -- | -- |
| *Pandorina* sp. | -- | 0.2 | -- | -- | -- | 1.5 |
| *Pediastrum* sp. | 0.9 | 0.2 | -- | -- | -- | -- |
| *Scenedesmus* sp. | 2.1 | 4.4 | 1.2 | 1.3 | 1.6 | 7.4 |
| *Staurastrum* sp. | 0.3 | -- | -- | 0.2 | 0.4 | 4.4 |
| *Tetraedron* sp. | -- | 0.1 | 0.2 | -- | -- | -- |
| *Volvox* sp. | -- | 0.3 | -- | 0.7 | -- | 39.7 |
| Unidentified chlorophyte | -- | -- | 1.2 | 1.8 | 1.0 | -- |
| Euglenophyta | 2.7 | 4.0 | 2.2 | 1.0 | 3.2 | 12.9 |
| Euglenophyceae | | | | | | |
| *Euglena* sp. | -- | 0.2 | -- | -- | -- | 5.3 |
| *Phacus* sp. | 0.3 | 1.7 | 0.5 | 1.0 | 0.1 | 7.6 |
| *Trachelomonas* sp. | -- | -- | -- | -- | 0.4 | -- |
| Unidentified flagellate | 2.4 | 2.1 | 1.7 | -- | 2.7 | -- |

TABLE II-13 (Continued)

Page 2 of 2

| Taxa | Brushy Creek | | | Oak Creek | | |
|---|---|---|---|---|---|---|
| | B-1[a] | B-2 | B-3 | 0-1 | 0-2 | 0-3 |
| Pyrrophyta | -- | -- | -- | 0.4 | -- | 4.4 |
| Dinophyceae | | | | | | |
| *Ceratium* sp. | -- | -- | -- | 0.4 | -- | -- |
| *Gymnodinium* sp. | -- | -- | -- | -- | -- | 4.4 |
| Chrysophyta | 57.9 | 22.0 | 30.6 | 6.3 | 12.7 | 70.8 |
| Chrysophyceae | | | | | | |
| *Chrysococcus* sp. | 0.6 | 1.6 | 1.7 | 1.2 | 0.4 | 21.0 |
| Bacillariophyceae | | | | | | |
| *Amphora* sp. | 1.6 | -- | -- | -- | -- | -- |
| *Cocconeis* sp. | -- | -- | 0.5 | -- | -- | -- |
| *Cyclotella* sp. | 8.3 | 2.5 | 4.4 | 0.2 | 0.7 | -- |
| *Cymbella* sp. | 0.9 | 0.1 | -- | -- | 0.8 | -- |
| *Diatoma* sp. A | 3.3 | -- | -- | -- | 0.6 | -- |
| *Diatoma* sp. B | -- | -- | -- | -- | 0.3 | -- |
| *Diploneis* sp. | -- | 0.4 | -- | -- | -- | -- |
| *Eunotia* sp. | -- | -- | 1.0 | 0.2 | -- | -- |
| *Fragilaria* sp. | -- | 0.3 | 0.7 | -- | -- | -- |
| *Gomphonema* sp. | 3.0 | -- | 0.2 | -- | -- | -- |
| *Gyrosigma* sp. | -- | 0.3 | 0.5 | 0.2 | 0.1 | -- |
| *Mastigloia* sp. | 0.6 | -- | -- | -- | -- | -- |
| *Melosira* sp. | 8.6 | 1.2 | 2.3 | -- | 1.1 | 4.4 |
| *Meridion* sp. | -- | 0.3 | 0.2 | -- | 0.1 | -- |
| *Navicula* sp. A | 10.7 | 4.0 | 4.3 | 1.3 | 1.8 | 7.5 |
| *Navicula* sp. B | 6.8 | 2.9 | 3.3 | 0.5 | 1.3 | -- |
| *Navicula* sp. C | 0.6 | 0.2 | 2.4 | 0.3 | 0.6 | -- |
| *Navicula* sp. D | -- | 0.3 | 0.5 | -- | -- | -- |
| *Navicula* sp. E | -- | -- | 0.5 | -- | -- | -- |
| *Navicula* sp. F | -- | -- | 0.2 | -- | -- | -- |
| *Nitzschia* sp. A | 2.4 | 2.9 | 1.4 | 0.5 | 1.2 | 7.4 |
| *Nitzschia* sp. B | 0.9 | 0.6 | 0.6 | 0.4 | 0.4 | 5.3 |
| *Nitzschia* sp. C | -- | 0.1 | 0.6 | -- | -- | -- |
| *Nitzschia* sp. D | -- | -- | 0.2 | -- | -- | -- |
| *Pinnularia* sp. A | 2.4 | 0.7 | 1.2 | 0.5 | 0.1 | 4.5 |
| *Pinnularia* sp. B | 2.7 | 0.4 | 0.6 | -- | -- | 4.4 |
| *Pinnularia* sp. C | -- | 0.1 | -- | -- | -- | -- |
| *Stauroneis* sp. | 0.6 | -- | 0.6 | -- | -- | -- |
| *Synedra* sp. A | 3.3 | 1.6 | 2.5 | 0.5 | 1.5 | 13.3 |
| *Synedra* sp. B | 0.6 | 0.7 | 0.2 | 0.5 | 1.4 | 3.0 |
| *Synedra* sp. C | -- | 0.8 | -- | -- | 0.3 | -- |
| Phytoplankton Density | 68.7 | 48.0 | 41.6 | 15.6 | 22.1 | 203.5 |
| Total Number of Taxa | 27 | 36 | 37 | 25 | 28 | 23 |
| Species Diversity ($\bar{d}$) | 3.43 | 3.82 | 4.00 | 3.89 | 3.85 | 3.86 |

---

[a] Data from one sample only. All other data points represent the average of data from two replicate samples.

# TABLE II-14

## AQUATIC MACROPHYTES AND SHORELINE VEGETATION ASSOCIATED WITH STREAMS ON THE MISSISSIPPI CHEMICAL CORPORATION SITE
## 1980

Page 1 of 2

| | Brushy Creek | | | Oak Creek | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | B-1 | B-2 | B-3 | 0-1 | 0-2 | 0-3 | Form[a] | Habitat[b] |
| Alternanthera philoxeroides<br>Alligator weed | | x | x | | | | E | B |
| Bacopa caroliniana<br>Water-mint | x | x | x | | | | E | B |
| Egeria densa<br>Brazilian elodea | x | | | | | | S | S |
| Eichhornia crassipes<br>Water hyacinth | | | x | | x | x | FF | B,S |
| Eleocharis acicularis<br>Spikerush | | | x | | x | x | E,S | B,S |
| Hydrocotyle umbellata<br>Water pennywort | | x | x | | x | x | E | B |
| Iris hexagona<br>Blue flag | | | x | | x | | E | B |
| Juncus effusus<br>Soft rush | | | | | x | | E | B |
| Ludwigia palustris<br>Marsh purslane | x | | x | x | x | x | E,S | B,S |
| Micranthemum umbrosum<br>Baby's tears | | | x | | | | E,S | B |

TABLE II-14 (Continued)

Page 2 of 2

| Species | Brushy Creek |  |  | Oak Creek |  |  | Form[a] | Habitat[b] |
|---|---|---|---|---|---|---|---|---|
|  | B-1 | B-2 | B-3 | 0-1 | 0-2 | 0-3 |  |  |
| *Myriophyllum aquaticum*<br>Parrot's-feather |  | x | x |  |  |  | S,E | B,S |
| *Nuphar advena*<br>Spatterdock |  |  | x |  |  |  | S,FL | B,S |
| *Oedogonium* sp.<br>Green alga | x | x | x |  |  |  | S | S |
| *Panicum hemitomon*<br>Maidencane |  | x | x |  |  |  | E | B |
| *Paspalum fluitans*<br>Water paspalum |  |  |  | x |  |  | E | B,S |
| *Pistia stratiodes*<br>Water-lettuce |  |  | x |  |  |  | FF | B,S |
| *Polygonum hydropiperoides*<br>Smartweed | x |  | x |  |  | x | E | B |
| *Pontederia cordata*<br>Pickerel weed | x |  | x | x | x |  | E | B |
| *Salix caroliniana*<br>Carolina willow |  |  | x |  |  |  | E | B |
| *Spirogyra* sp.<br>Green alga | x | x | x |  |  |  | S | S |

---

[a] E = Emergent; FF = Free-floating; S = Submerged;
FL = Floating-leaved.

[b] B = Found along bank or littoral zone.
S = Found well within stream channel.

TABLE II-15

ZOOPLANKTON COLLECTED FROM THE MISSISSIPPI CHEMICAL CORPORATION SITE, APRIL 1980[a]

Page 1 of 2

| Species | Brushy Creek | | | Oak Creek | | |
|---|---|---|---|---|---|---|
| | B-1 | B-2 | B-3 | O-1 | O-2 | O-3 |
| Rotatoria | 21.97 | 5.75 | 2.09 | 2.07 | 2.63 | 4.48 |
| *Asplanchna* sp. | 0.09 | -- | -- | -- | 0.03 | 0.15 |
| *Brachionus angularis* | -- | -- | -- | -- | 0.05 | 0.07 |
| *B. calyciflorus* | -- | 0.05 | -- | 1.23 | 0.03 | -- |
| *B. quadridentatus* | -- | 0.03 | 0.05 | -- | -- | 0.05 |
| *Cephalodella* sp. | 0.34 | 0.03 | -- | -- | 0.08 | 0.05 |
| *Conochilus unicornis* | 0.09 | -- | 0.03 | -- | 0.12 | 0.38 |
| *Euchlanis* sp. | 8.33 | 0.24 | 0.03 | 0.10 | -- | -- |
| *Filinia longiseta* | -- | 0.03 | 0.03 | -- | 0.03 | -- |
| *Hexarthra* sp. | -- | -- | -- | -- | 0.03 | -- |
| *Kellicottia bostoniensis* | -- | -- | -- | -- | -- | 0.10 |
| *Keratella cochlearis* | -- | -- | 0.08 | -- | -- | 0.05 |
| *K. quadrata* | -- | 0.03 | -- | 0.05 | -- | -- |
| *K. serrulata* | -- | 0.05 | -- | -- | -- | -- |
| *Lecane luna* | 0.34 | 0.81 | 0.55 | 0.03 | 0.48 | 0.15 |
| *Lepadella* sp. | 0.50 | 0.43 | 0.24 | 0.10 | 0.38 | -- |
| *Mytilina* sp. | -- | 0.05 | 0.10 | 0.05 | 0.10 | 0.08 |
| *Monostyla bulla* | 0.67 | 0.57 | 0.41 | 0.10 | 0.22 | 0.07 |
| *Platyas patulus* | 0.09 | 0.31 | 0.03 | -- | 0.08 | 0.15 |
| *P. quadricornus* | 0.42 | 0.34 | 0.10 | 0.03 | 0.10 | 1.62 |
| *Polyarthra* sp. | 1.00 | 0.93 | 0.17 | 0.08 | 0.43 | 0.86 |
| *Scaridium longicaudum* | 0.09 | 0.07 | 0.05 | -- | 0.05 | 0.38 |
| *Synchaeta* sp. | -- | 0.07 | -- | -- | -- | 0.22 |
| *Testudinella* sp. | 0.17 | 0.22 | 0.12 | 0.10 | 0.17 | 0.07 |
| *Trichocerca elongata* | 1.42 | 0.48 | 0.10 | -- | 0.15 | -- |
| *Trichotria* sp. | 0.50 | 0.15 | -- | -- | 0.10 | 0.03 |
| Unidentified rotifer[b] | 7.92 | 0.86 | -- | 0.20 | -- | -- |
| Cladocera | 1.43 | 0.24 | 0.45 | 0.18 | 0.28 | 0.38 |
| *Alona guttata* | 0.42 | 0.14 | 0.22 | 0.08 | 0.17 | 0.08 |
| *Alonella dadayi* | 0.17 | -- | 0.05 | 0.10 | -- | -- |
| *Camptocercus rectirostris* | -- | -- | 0.03 | -- | 0.03 | -- |
| *Ceriodaphnia* sp. | -- | -- | -- | -- | -- | 0.12 |
| *Chydorus sphaericus* | 0.58 | 0.05 | 0.10 | -- | 0.08 | 0.15 |
| *Kurzia latissima* | 0.09 | -- | -- | -- | -- | 0.03 |
| *Leydigia quadrangularis* | 0.17 | -- | -- | -- | -- | -- |
| *Grimaldina brazzai* | -- | 0.05 | 0.05 | -- | -- | -- |

TABLE II-15(Continued) Page 2 of 2

| Species | Brushy Creek | | | Oak Creek | | |
|---|---|---|---|---|---|---|
| | B-1 | B-2 | B-3 | 0-1 | 0-2 | 0-3 |
| Copepoda | 12.60 | 9.54 | 6.53 | 1.74 | 5.99 | 4.75 |
| *Eucyclops agilis* | 0.42 | 0.05 | 0.05 | 0.03 | 0.07 | 0.03 |
| *Macrocyclops albidus* | 0.33 | -- | 0.03 | -- | -- | -- |
| *Tropocyclops prasinus* | 0.09 | 0.08 | -- | -- | 0.03 | 0.10 |
| Cyclopoid copepodite | 2.67 | 0.55 | 0.45 | 0.13 | 0.55 | 0.57 |
| Calanoid copepodite | 0.17 | -- | -- | -- | -- | 0.03 |
| Nauplii | 8.92 | 8.86 | 6.00 | 1.58 | 5.34 | 4.02 |
| Zooplankton Density | 36.00 | 15.53 | 9.07 | 3.99 | 8.90 | 9.61 |
| Total Number of Taxa[c] | 23 | 25 | 22 | 14 | 23 | 23 |
| Species Diversity ($\bar{d}$)[c] | 2.88 | 3.85 | 3.83 | 2.61 | 3.97 | 3.43 |

---

[a] Values represent the average number of organisms/liter found in two replicate samples.

[b] Probably a member of the group *Bdelloidea*.

[c] Does not include the immature copepod forms (nauplii, calanoid and cyclopoid copepodites).

## TABLE II-16

## BENTHIC MACROINVERTEBRATES COLLECTED FROM STREAMS ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY APRIL 1980[a]

Page 1 of 4

| Taxa | Brushy Creek | | | Oak Creek | | |
|---|---|---|---|---|---|---|
| | B-1 | B-2 | B-3 | O-1 | O-2 | O-3 |
| Arthropoda | | | | | | |
| Insecta | | | | | | |
| Diptera | | | | | | |
| *Ablabesmyia* sp. | 26 | 13 | 16 | 13 | 9 | 29 |
| *Bezzia*-*Probezzia* sp. | 38 | 16 | 26 | 22 | 26 | 32 |
| Ceratopogonidae | - | 6 | 3 | - | 3 | - |
| Chironominae | 35 | 3 | 16 | - | 13 | 3 |
| Chironomini | - | - | 13 | - | - | - |
| *Chironomus* sp. | - | - | 13 | 6 | 86 | 303 |
| *Cladotanytarsus* sp. | 3 | 22 | 42 | - | - | 10 |
| *Coelotanypus* sp. | 48 | - | 51 | - | 29 | 22 |
| *Cricotopus* sp. | 6 | - | - | - | - | - |
| *Cryptochironomus* sp. | 19 | 32 | 51 | 16 | - | - |
| *Cryptocladopelma* sp. | - | 6 | 13 | - | 3 | - |
| *Dicrotendipes* sp. | - | - | - | 3 | 3 | 10 |
| *Einfeldia* sp. | - | - | - | 3 | - | - |
| *Harnischia* sp. | 3 | - | - | 3 | 6 | - |
| *Micropsectra* sp. | 3 | 25 | 115 | - | - | - |
| Orthocladinae | 3 | - | - | - | - | - |
| *Paralauterborniella* sp. | 3 | - | 13 | - | - | - |
| Pentineurini | 10 | - | - | 10 | - | 7 |
| *Polypedilum* sp. | 89 | 247 | 577 | 71 | 19 | 48 |
| *Procladius* sp. | - | - | - | - | 51 | 42 |
| *Psectrocladius* sp. | - | - | 13 | - | - | - |
| *Rheotanytarsus* sp. | 166 | 29 | - | 23 | - | 32 |
| Simulidae | 6 | 32 | - | - | - | - |
| Tanypodinae | 6 | 6 | - | - | - | - |
| *Tanypus* sp. | - | - | - | - | - | 3 |
| Tanytarsini | 16 | - | 13 | - | 6 | 16 |
| *Tanytarsus* sp. | 328 | 45 | 143 | 44 | 105 | 332 |
| Tipulinae | - | - | 13 | - | - | - |
| *Xenochironomus* sp. | - | 6 | - | - | - | - |
| Unidentified dipteran sp. | 3 | - | - | 7 | - | 3 |

| Taxa | Brushy Creek B-1 | Brushy Creek B-2 | Brushy Creek B-3 | Oak Creek 0-1 | Oak Creek 0-2 | Oak Creek 0-3 |
|---|---|---|---|---|---|---|
| Ephemeroptera | | | | | | |
| *Baetis* sp. | - | 35 | - | - | 3 | 3 |
| *Caenis* sp. | 190 | - | 13 | 3 | 152 | 3 |
| *Siphlonurus* sp. | - | - | - | - | - | 7 |
| Trichoptera | | | | | | |
| *Cheumatopsyche* sp. | 26 | 3 | - | 16 | - | - |
| *Hydropsyche* sp. | - | 6 | - | - | - | - |
| Hydropsychidae | - | - | 3 | 3 | - | - |
| *Oecetis* sp. | 13 | 6 | 13 | - | - | 7 |
| *Oxyethira* sp. | 3 | - | - | - | - | - |
| Lepidoptera | | | | | | |
| *Paragyractis* sp. | 16 | - | - | - | - | - |
| *Parapoynx* sp. | 3 | - | - | - | - | - |
| Odonata | | | | | | |
| *Gomphus* sp. | - | 6 | - | - | - | - |
| *Macromia* sp. | - | 3 | 3 | - | - | - |
| *Macrothemis* sp. | - | - | - | - | 6 | - |
| *Nehalennia* sp. | 16 | 3 | 13 | - | - | - |
| *Pachydiplax longipennis* | - | - | - | - | 7 | - |
| *Perithemis* sp. | - | - | - | - | 19 | 3 |
| *Tetragoneuria* sp. | - | - | 6 | - | - | - |
| Coleoptera | | | | | | |
| Dytiscidae | - | - | - | - | - | 7 |
| *Elimini* sp. | 7 | - | - | - | - | - |
| *Haliplidae* | - | - | 3 | - | - | - |
| Collembola | 3 | - | - | 3 | 3 | 3 |

TABLE II-16 (Continued)

Page 3 of 4

| Taxa | Brushy Creek | | | Oak Creek | | |
|---|---|---|---|---|---|---|
| | B-1 | B-2 | B-3 | O-1 | O-2 | O-3 |
| Crustacea | | | | | | |
| Amphipoda | | | | | | |
| *Hyalella azteca* | 1655 | 102 | 60 | 45 | 89 | 105 |
| Isopoda | | | | | | |
| *Asellus* sp. | - | - | - | 127 | - | - |
| Decapoda | | | | | | |
| *Palaemonetes poludosus* | - | 6 | 86 | 3 | 29 | - |
| Cnidaria | | | | | | |
| *Hydra* sp. | 13 | - | 13 | - | - | - |
| Nematoda | 147 | 6 | 25 | - | 3 | 13 |
| Annelida | | | | | | |
| Oligochaeta | | | | | | |
| *Aulophorus* sp. | - | - | - | - | - | 3 |
| *Dero* sp. | 249 | 6 | 628 | 54 | 111 | 102 |
| *Limnodrilus hoffmeisteri* | 64 | 80 | 252 | 207 | 258 | 13 |
| *Limnodrilus* sp. | 2312 | 160 | 367 | 787 | 1387 | 90 |
| *Lumbriculidae* | 93 | 13 | 48 | 68 | 48 | 6 |
| Naididae | - | - | - | 3 | - | 7 |
| *Slavina* sp. | 3 | - | - | 41 | - | - |
| *Stylaria* sp. | - | - | - | 3 | - | - |
| *Immature* tubificids | 2216 | 542 | 670 | 169 | 169 | 163 |
| Hirudinea | | | | | | |
| Unidentified sp. | 41 | 6 | 51 | 57 | 93 | 16 |

TABLE II-16 (Continued)

Page 4 of 4

| Taxa | Brushy Creek B-1 | Brushy Creek B-2 | Brushy Creek B-3 | Oak Creek 0-1 | Oak Creek 0-2 | Oak Creek 0-3 |
|---|---|---|---|---|---|---|
| Mollusca | | | | | | |
| Bivalvia | | | | | | |
| *Corbicula* sp. | - | 10 | - | - | - | - |
| *Sphaeriidae* | 10 | 38 | 447 | 529 | 1486 | 708 |
| Unionaceae | - | 3 | 3 | - | - | - |
| Gastropoda | | | | | | |
| *Ferrisia* | 188 | 86 | 13 | 3 | 549 | 3 |
| Pleuroceridae | 51 | - | 16 | - | - | - |
| *Pomacea* | - | 6 | - | - | 6 | - |
| Unidentified gastropod | 7 | - | 3 | 6 | 61 | 7 |
| Macroinvertebrate Density | 8137 | 1614 | 3867 | 2348 | 4838 | 2161 |
| Diversity ($\bar{d}$) | 2.9 | 3.5 | 3.7 | 3.2 | 3.1 | 3.4 |
| Equitability (e) | 0.28 | 0.65 | 0.53 | 0.40 | 0.37 | 0.41 |

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[a] Values represent the average species density/m$^2$ from duplicate Ponar grab samples taken along both stream banks and in the center of the stream.

## TABLE II-17

## MACROINVERTEBRATES COLLECTED IN DRIFT NETS FROM STREAMS ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY APRIL 1980[a]

Page 1 of 3

| Taxa | Brushy Creek B-1 | Brushy Creek B-2 | Brushy Creek B-3 | Oak Creek O-1 | Oak Creek O-2 | Oak Creek O-3 |
|---|---|---|---|---|---|---|
| Arthropoda | | | | | | |
| Insecta | | | | | | |
| Diptera | | | | | | |
| *Ablabesmyia* sp. | - | 3 | - | 3 | 17 | 4 |
| Ceratopogonidae | - | 1 | - | - | - | - |
| *Chaoborus* sp. | - | 18 | - | 2 | 6 | - |
| Chironominae | - | 1 | - | - | - | - |
| *Chironomus* sp. | - | - | - | 2 | - | 7 |
| *Cladotanytarsus* sp. | - | - | 1 | - | - | - |
| *Corynoneura* sp. | 1 | - | - | - | - | - |
| *Cricotopus* sp. | - | - | - | - | 1 | - |
| *Dicrotendipes* sp. | - | 1 | - | - | 1 | - |
| Gerridae | - | 1 | - | - | - | - |
| Goeloichironomus sp. | - | - | - | - | 1 | 4 |
| *Labrudinia floridana* | 5 | - | - | - | - | - |
| *Libellula* sp. | - | - | 1 | - | - | - |
| Naucoridae | 1 | 1 | - | - | 1 | - |
| Pentineurini | - | - | - | - | - | 1 |
| *Polypedilum* sp. | 4 | 1 | - | 13 | 7 | 1 |
| *Psectrocladius* sp. | - | - | - | 1 | - | - |
| *Rheotanytarsus* sp. | 1 | - | - | - | - | - |
| Tanypodinae | - | 4 | - | 1 | - | - |
| *Tanypus* sp. | - | - | - | - | - | 1 |
| Tanytarsini | - | - | - | - | - | 1 |
| *Tanytarsus* sp. | 5 | 1 | - | 5 | - | 4 |
| Ephemeroptera | | | | | | |
| *Baetis* sp. | 5 | 5 | 4 | - | 1 | 8 |
| *Caenis* sp. | - | 12 | 2 | - | 56 | 2 |
| Trichoptera | | | | | | |
| *Oecetis* sp. | - | - | - | 1 | - | - |

| Taxa | Brushy Creek B-1 | Brushy Creek B-2 | Brushy Creek B-3 | Oak Creek O-1 | Oak Creek O-2 | Oak Creek O-3 |
|---|---|---|---|---|---|---|
| Odonata | | | | | | |
| *Anisoptera* sp. | - | - | - | 1 | - | - |
| *Micrathyria* sp. | - | - | - | 1 | - | - |
| *Zygoptera* sp. | - | 1 | - | - | - | - |
| Coleoptera | | | | | | |
| *Coptotomus* sp. | 4 | 27 | - | 1 | 127 | 6 |
| Unidentified sp. | - | 2 | - | - | 8 | 5 |
| Arachnida | | | | | | |
| *Hydracarina* sp. | - | - | - | - | 1 | - |
| Crustacea | | | | | | |
| Mysidacea | - | - | 1 | - | - | - |
| Amphipoda | | | | | | |
| *Crangonyx* sp. | - | - | - | 1 | - | - |
| *Hyalella* sp. | - | 246 | 2 | 2 | 134 | 60 |
| Isopoda | | | | | | |
| *Asellus* sp. | - | - | - | - | - | 4 |
| Decapoda | | | | | | |
| *Palaemonetes* sp. | - | - | 2 | - | - | - |
| *Procambarus* sp. | - | - | 4 | - | - | - |
| Cnidaria | | | | | | |
| *Hydra* sp. | - | - | - | - | - | 1 |

TABLE II-17 (Continued)

Page 3 of 3

| Taxa | Brushy Creek | | | Oak Creek | | |
|---|---|---|---|---|---|---|
| | B-1 | B-2 | B-3 | 0-1 | 0-2 | 0-3 |
| Annelida | | | | | | |
| Oligochaeta | | | | | | |
| *Dero* sp. | 2 | - | - | 3 | - | 12 |
| *Lumbriculidae* | - | - | - | - | - | 1 |
| *Nais* sp. | 2 | - | - | - | - | 3 |
| *Pristina* sp. | 1 | - | - | - | 2 | 2 |
| *Immature* tubificids | - | 1 | 1 | - | - | 7 |
| Hirudinea | | | | | | |
| Unidentified sp. | - | - | - | 1 | - | - |
| Mollusca | | | | | | |
| Bivalvia | | | | | | |
| Unidentified bivalve | - | - | - | - | - | 1 |
| Gastropoda | | | | | | |
| *Ferrisia* sp. | - | - | - | 2 | - | 2 |
| TOTAL ORGANISMS | 31 | 326 | 18 | 40 | 363 | 137 |

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[a] Densities represent numbers collected over a 24-hour period.

## TABLE II-18

## VOLATILE SOLIDS ASSOCIATED WITH SEDIMENTS FROM VARIOUS STATIONS ON BRUSHY (B-1 THROUGH B-3) AND OAK (O-1 THROUGH O-3) CREEKS ON MCC SITE OCTOBER 1980

| Station | B-1 | B-2 | B-3 | O-1[a] | O-2 | O-3 |
|---|---|---|---|---|---|---|
| Percent[b] | 1.25 | 0.6 | 0.45 | 1.4 | 0.9 | 1.95 |

[a] Sample collected from dry stream bed.

[b] Values represent average of two samples for each station, one from near shore and one in mid-channel.

## TABLE II-19

## FISH COLLECTED IN BRUSHY AND OAK CREEKS ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY
## APRIL 1980[a]

Page 1 of 2

| Family<br>Common Name | Scientific Name | Brushy Creek |  |  | Oak Creek |  |  |
|---|---|---|---|---|---|---|---|
|  |  | B-1 | B-2 | B-3 | 0-1 | 0-2 | 0-3 |
| Lepisosteidae |  |  |  |  |  |  |  |
| Florida gar | Lepisosteus platyrhincus | - | 4 | - | - | 1 | - |
| Alligator gar | L. spatula | - | 7 | 1 | - | 1 | 1 |
| Amiidae |  |  |  |  |  |  |  |
| Bowfin | Amia calva | - | 8 | 1 | - | 5 | 4 |
| Cyprinidae |  |  |  |  |  |  |  |
| Golden shiner | Notemigonus crysoleucas | 2 | 1 | 1 | - | - | - |
| Ironcolor shiner | Notropis chalybaeus | 1 | - | 15 | - | - | - |
| Taillight shiner | N. maculatus | 2 | - | - | - | - | - |
| Unidentified shiner | Notropis sp. | 6 | - | - | - | - | - |
| Catostomidae |  |  |  |  |  |  |  |
| Lake chubsucker | Erimyzon sucetta | - | - | 1 | - | 1 | - |
| Ictaluridae |  |  |  |  |  |  |  |
| Yellow bullhead | Ictalurus natalis | - | 33 | 9 | - | 3 | 2 |
| Brown bullhead | I. nebulosus | - | - | - | - | 20 | 2 |
| Tadpole madtom | Noturus gyrinus | - | - | 1 | - | - | - |
| Clariidae |  |  |  |  |  |  |  |
| Walking catfish | Clarias batrachus | - | - | 1 | - | - | - |
| Cyprinodontidae |  |  |  |  |  |  |  |
| Golden topminnow | Fundulus chrysotus | 1 | - | 3 | - | - | - |
| Seminole killifish | F. seminolis | - | 1 | - | 10 | - | 2 |
| Flagfish | Jordanella floridae | 1 | - | 1 | - | 1 | - |
| Bluefin killifish | Lucania goodei | 1 | - | - | - | 1 | - |

TABLE II-19 (Continued)

Page 2 of 2

| Family<br>Common Name | Scientific Name | Brushy Creek B-1 | Brushy Creek B-2 | Brushy Creek B-3 | Oak Creek 0-1 | Oak Creek 0-2 | Oak Creek 0-3 |
|---|---|---|---|---|---|---|---|
| Poeciliidae | | | | | | | |
| Mosquitofish | *Gambusia affinis* | 25 | 857 | 68 | 31 | 178 | 464 |
| Least killifish | *Heterandria formosa* | 42 | 571 | 40 | 7 | 10 | 122 |
| Sailfin molly | *Poecilia latipinna* | 2 | 3 | - | - | - | 4 |
| Atherinidae | | | | | | | |
| Brook silverside | *Labidesthes sicculus* | 1 | - | - | - | - | - |
| Centrarchidae | | | | | | | |
| Banded pygmy sunfish | *Elassoma zonatum* | - | - | - | - | - | 3 |
| Bluespotted pygmy sunfish | *Enneacanthus gloriosus* | 1 | - | - | - | - | - |
| Warmouth | *Lepomis gulosus* | - | 5 | 4 | - | - | 13 |
| Bluegill | *L. macrochirus* | - | 1 | 1 | - | 1 | - |
| Redear sunfish | *L. microlophus* | - | 1 | - | - | 1 | - |
| Spotted sunfish | *L. punctatus* | - | - | 1 | - | 1 | - |
| Immature sunfish | *Lepomis* sp. | 1 | - | 1 | - | - | - |
| Largemouth bass | *Micropterus salmoides* | 1 | 1 | 1 | - | 3 | - |
| Percidae | | | | | | | |
| Brown darter | *Etheostoma edwini* | - | - | - | - | - | 1 |
| Swamp darter | *E. fusiforme* | 1 | - | 1 | - | - | - |
| Total | | 88 | 1493 | 151 | 48 | 227 | 618 |

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[a] Includes fish captured by seining and gill netting.

## TABLE 11-20

## STATUS, PREFERRED HABITAT AND POTENTIAL IMPACTS FOR THREATENED OR ENDANGERED ANIMALS OCCURRING OR POTENTIALLY OCCURRING ON THE MISSISSIPPI CHEMICAL CORPORATION PROPERTY, HARDEE COUNTY

Page 1 of 3

| Scientific Name | Common Name | Status[a] | Preferred Habitat |  |  | Likelihood of Occurrence | Probable Impacts |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Feeding | Nesting | Roosting |  | Short-Term | Long-Term |
| MAMMALS |  |  |  |  |  |  |  |  |
| Eptesicus fuscus | Big brown bat | R | Open fields, lake edges | N/A | Old buildings | Low | Habitat loss | Beneficial habitat gain |
| Felis concolor coryi | Florida panther | End. App. I | All habitats | Undisturbed wilderness areas | N/A | Moderate | Habitat loss | Limited habitat recovery |
| Mustela frenata peninsulae | Florida weasel | R | Variable habitats | Variable habitats | N/A | Very low | Habitat loss | None |
| Neofiber alleni | Round-tailed muskrat | SC | Fresh marsh | Fresh marsh | N/A | Very high | Habitat loss | Limited habitat recovery |
| Plecotus rafinesquei | Southeastern big-eared bat | R | Wooded lands | N/A | Old shacks and trees in wooded lands | Moderate | Habitat loss | Limited habitat recovery |
| Sciurus niger shermani | Sherman's fox squirrel | T | Sandhills, palmetto range | In trees | N/A | Present | Habitat loss | Limited habitat recovery |
| Ursus americanus floridanus | Florida black bear | T | Dense woodlands, swamps, and thickets | Dense woodlands, swamps, and thickets | N/A | High | Habitat loss | Limited habitat recovery |
| Peromyscus floridanus | Florida mouse | T | Sandpine scrub, long-leaf pine-Turkey oak | Gopher tortoise burrows | N/A | High | Habitat loss | Habitat loss |
| BIRDS |  |  |  |  |  |  |  |  |
| Accipiter cooperii | Cooper's hawk | SC | Woodlands, especially mesic hammock & swamps | Trees in upland woods | N/A | Present | Habitat loss disturbance | Limited habitat recovery |
| Buteo brachyurus fuliginosus | Short-tailed hawk | R | Prairies, open woodland, marsh | Swamps, palmetto range | N/A | Low | Habitat loss disturbance | Limited habitat recovery |
| Campephilus principalis | Ivory-billed woodpecker | End. | Undisturbed, mature hardwood swamp | Undisturbed, mature swamp forest | N/A | Very low | Minor habitat loss | None |
| Caracara cheriway audubonii | Audubon's caracara | T | Open prairies | Cabbage palms | N/A | High | Habitat loss | Partial habitat recovery |
| Casmerodius albus | Common egret | SC | Shorelines, swamps, fresh marsh | Trees and tall brush in swamps | Wooded swamps and shorelines | Present | Habitat loss | Partial habitat recovery |
| Dendrocopus borealis | Red-cockaded woodpecker | End. | Pine flatwoods, palmetto range | Overmature pines with redheart disease | N/A | Low | Minor habitat loss | None |
| Dendrocopus villosus audubonii | Southern hairy woodpecker | SC | Dense woodlands | Tree cavities | N/A | Low | Habitat loss | Limited habitat recovery |
| Egretta thula | Snowy egret | SC | Shorelines, swamps, fresh marsh, and moist fields | Trees and tall brush in swamps and shorelines | Trees and tall brush in swamps and shorelines | Present | Habitat loss | Partial habitat recovery |
| Elanus caeruleus majusculus | White-tailed kite | R | Open woodlands, pasture, prairie and marshes | Oak trees | N/A | Very low | Habitat loss | Beneficial habitat gain |

TABLE II-20 (Continued)

| Scientific Name | Common Name | Status^a | Preferred Habitat |  |  | Likelihood of Occurrence | Probable Impacts |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Feeding | Nesting | Roosting |  | Short-Term | Long-Term |
| Eudocimus albus | White ibis | SC | Shorelines, swamps, fresh marsh | Wooded swamps and shorelines | Wooded swamps and shorelines | Present | Habitat loss | Limited habitat recovery |
| Aramus guarauna | Limpkin | SC | Shorelines, swamps, fresh water | Brush and trees in marshes | Brush and trees in marshes | High | Habitat loss | Habitat loss |
| Aphelocoma coerulescens coerulescens | Florida scrub jay | T | Oak Scrub, sand pine scrub | Sand pine scrub, oak scrub | Sand pine scrub, oak scrub | Present | Habitat loss | Habitat loss |
| Falco columbarius | Merlin | SU | Open woodland | Trees | N/A | Moderate | Habitat loss | Beneficial habitat gain |
| Falco peregrinus tundrius | Arctic peregrine falcon | End. | Open land | N/A | N/A | Moderate | Habitat loss | Beneficial habitat gain |
| Falco sparverius paulus | Southeastern kestrel | T | Open land | Trees | N/A | Very high | Habitat loss | Beneficial habitat gain |
| Florida caerula | Little blue heron | SC | Shorelines, swamps | Brushy swamps and shorelines | Brushy swamps and shorelines | Present | Minor habitat loss | Partial habitat recovery |
| Grus canadensis pratensis | Florida sandhill crane | App. II, T | Fresh marsh, prairies, open range | Fresh marsh and shorelines | Prairies, ponds, fresh marsh, cypress heads | Present | Habitat loss | Limited habitat recovery |
| Haliaeetus l. leucocephalus | Southern bald eagle | End., App. I, Th. | Coastal and inland areas of open water | Tall pine in the vicinity of water | N/A | Very low | Minor habitat loss | Partial habitat recovery |
| Hydranassa tricolor | Louisiana heron | SC | Swamps, shorelines | Brush near open water, wamps | Wooded swamps and shorelines | Present | Minor habitat loss | Partial habitat recovery |
| Ixobrychus exilis | Least bittern | SC | Fresh marsh, shorelines | Fresh marsh, shorelines | N/A | Present | Habitat loss | Limited habitat recovery |
| Laterallus jamaicensis | Black rail | SU | Fresh marsh, brushy areas | Fresh marsh, brushy areas | N/A | Low | Habitat loss | Partial habitat recovery |
| Mycteria americana | Wood stork | E | Shorelines, fresh marsh, swamps, coastal marshes | Cypress swamps, trees adjacent to wetland habitats | Cypress swamps, mangroves | Present | Habitat loss | Limited habitat recovery |
| Nyctanassa violacea | Yellow-crowned night heron | SC | Swamps | Bushes and trees in swamps and shorelines | Bushes and trees in swamps and shorelines | Low | Habitat loss | None |
| Nycticorax nycticorax | Black-crowned night heron | SC | Swamps | Bushes and trees in swamps and shorelines | Bushes and trees in swamps and shorelines | Present | Habitat loss | None |
| Pandion haliaetus carolinensis | Osprey | App. II, T | Open bodies of water | Tall trees adjacent to water | N/A | Very low | Minor habitat loss | Beneficial habitat gain |
| Speotyto cunicularia floridana | Florida burrowing owl | SC | Prairies, sandhills, pastures, open woodland | Burrows in same habitat | N/A | Moderate | Habitat loss | Beneficial habitat gain |

Table II-20 (Continued)

| Scientific Name | Common Name | Status[a] | Preferred Habitat |  |  | Likelihood of Occurrence | Probable Impacts |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Feeding | Nesting | Roosting |  | Short-Term | Long-Term |
| *Plegadis falcinellus* | Glossy ibis | SC | Marshes, wet prairie | Marsh shoreline | Marsh shoreline | Present | Habitat loss | Habitat loss |
| REPTILES AND AMPHIBIANS |  |  |  |  |  |  |  |  |
| *Aligator mississippienis* | American alligator | End., Th. SC | Aquatic habitats with standing water | Lands adjoining aquatic habitats | N/A | Present | Habitat loss | Beneficial habitat gain |
| *Drymarchon corais couperi* | Eastern indigo snake | Th., T, SC | Xeric hammock, sandhill, mesic hammock, palmetto range | Xeric hammock, sandhill, mesic hammock, palmetto range | N/A | Present | Habitat loss | Limited habitat recovery |
| *Gopherus polyphemus* | Gopher tortoise | App. II, T | Xeric hammock, sandhills, sand pine scrub, dry palmetto range | Near burrow | N/A | Present | Habitat loss | Limited habitat recovery |
| *Neoseps reynoldsi* | Sand skink | T | Xeric hammock, sandhills, sand pine scrub | Xeric hammock, sandhills, sand pine scrub | N/A | Low | Habitat loss | Limited habitat recovery |
| *Rana aerolata aesopus* | Florida gopher frog | T | Xeric hammock, sandhills sand pine scrub | Fresh marsh | Burrows | High | Habitat loss | Limited habitat recovery |

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[a] Status - U.S. Department of Interior, Fish and Wildlife Service
End. = Endangered;
Th. = Threatened;
App. I = Species threatened with extinction, possibly as a result of trade;
App. II = Species which may be threatened with extinction unless trade is regulated.

Status - Florida Committee on Rare and Endangered Plants and Animals
E = Endangerd SC = Species of Special Concern
T = Threatened SU = Species Undetermined
R = Rare

## TABLE II-21

## PRESENT ACREAGES OF VEGETATIVE COMMUNITIES AND ACREAGES AFFECTED BY PROPOSED MINING, CLAY STORAGE, AND/OR RECLAMATION PLANS

| | Present Acreages[a] | Acres Undisturbed[b] | Acres Affected[c] |
|---|---|---|---|
| Upland Communities | | | |
| Pasture | 5,040 | 1,405 | 3,635 |
| Citrus grove | 28 | 0 | 28 |
| Palmetto range/Pine flatwoods | 6,002 | 1,932 | 4,070 |
| Mesic hammock | 770 | 333 | 437 |
| Xeric hammock | 30 | 18 | 12 |
| Subtotal | 11,870 | 3,688 | 8,182 |
| Wetland Communities | | | |
| Hardwood swamp | 490 | 35 | 455 |
| Fresh water marsh | 2,490 | 405 | 2,085 |
| Subtotal | 2,980 | 440 | 2,540 |
| TOTAL | 14,850 | 4,128 | 10,722 |

---

[a] Source: Winchester, 1980.

[b] The number of acres given are to be preserved from mining and clay storage activities.

[d] Includes areas affected by mining or clay storage.

## TABLE II-22

## TIME-PHASED PROGRESSION OF WETLANDS LOST AND STREAMS AFFECTED BY PROPOSED MINING AND CLAY STORAGE PLANS AND GAINS OF WETLANDS BY PROPOSED RECLAMATION PLAN

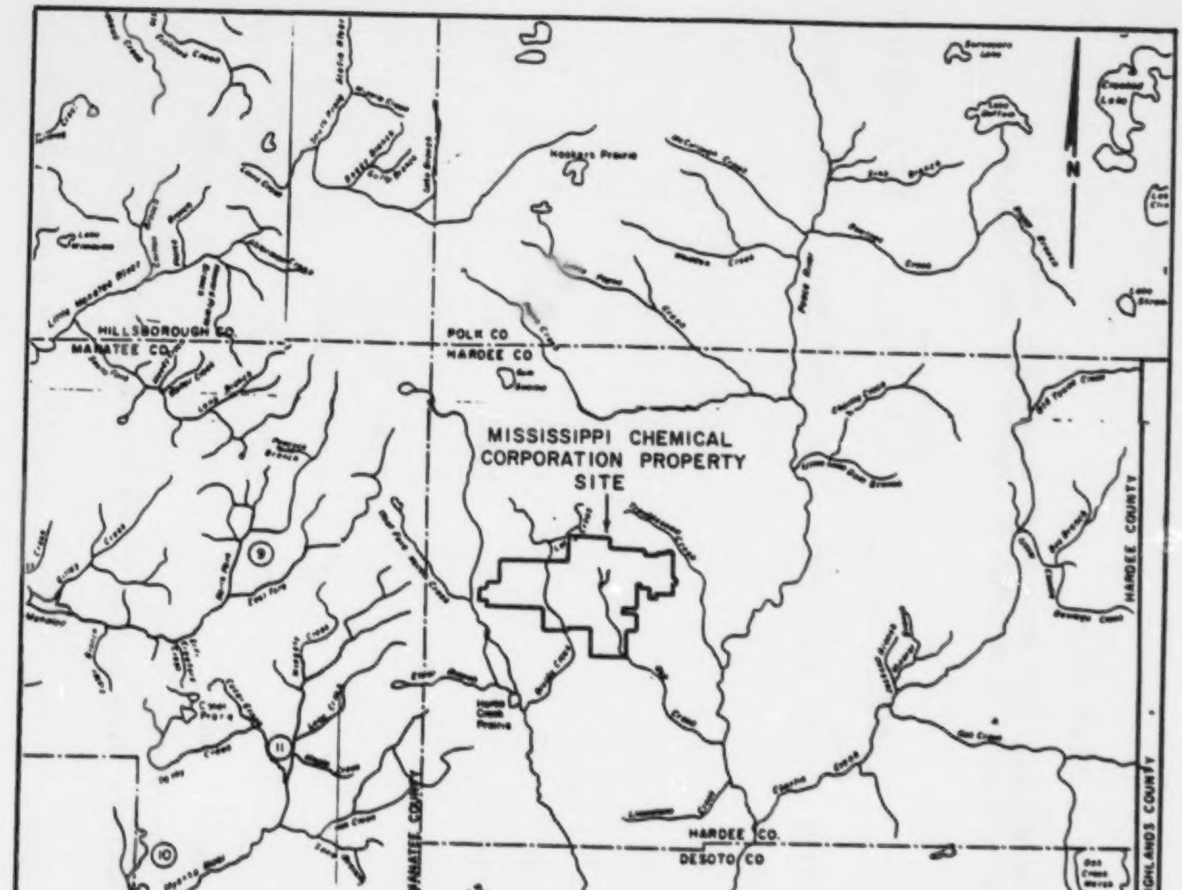
| | Marsh[a] | | | Swamp[a] | | | Cumulative Total Acres | | 5 cfs Streams[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Years | Mining | Clay Storage | Reclaimed[c] | Mining | Clay Storage | Reclaimed[c] | Lost | Reclaimed | Oak | Brushy |
| 1-4 | 212 | 98 | - | 25 | 11 | - | 346 | - | 0.25 | - |
| 5-8 | 178 | 100 | - | 41 | 6 | - | 671 | - | - | - |
| 9-12 | 173 | 42 | 112 | 95 | 34 | - | 1,015 | 112 | - | - |
| 13-16 | 89 | 63 | - | 30 | - | - | 1,197 | 112 | - | - |
| 17-20 | 317 | 69 | 12 | 105 | 17 | - | 1,705 | 124 | 1.0 | - |
| 21-24 | 196 | 45 | 201 | 56 | 1 | 32 | 2,003 | 357 | - | 0.5 |
| 25-28 | 149 | 54 | 216 | 28 | - | 25 | 2,234 | 598 | 0.5 | 0.75 |
| 29-32 | 300 | - | 719 | 6 | - | 76 | 2,540 | 1,393 | 1.1 | - |
| 33-36 | - | - | 158 | - | - | 165 | 2,540 | 1,716 | | |
| 37-40 | - | - | 202 | - | - | 92 | 2,540 | 2,010 | | |
| Totals | 1,614 | 471 | 1,620 | 386 | 69 | 390 | 2,540 | 2,010 | 2.85 | 1.25 |

---

[a] Numbers represent approximate acres of wetlands to be lost by mining or clay storage or to be gained by reclamation.

[b] Numbers represent approximate miles of stream bed affected. Prior to mining, new stream beds will be established to replace sections lost.

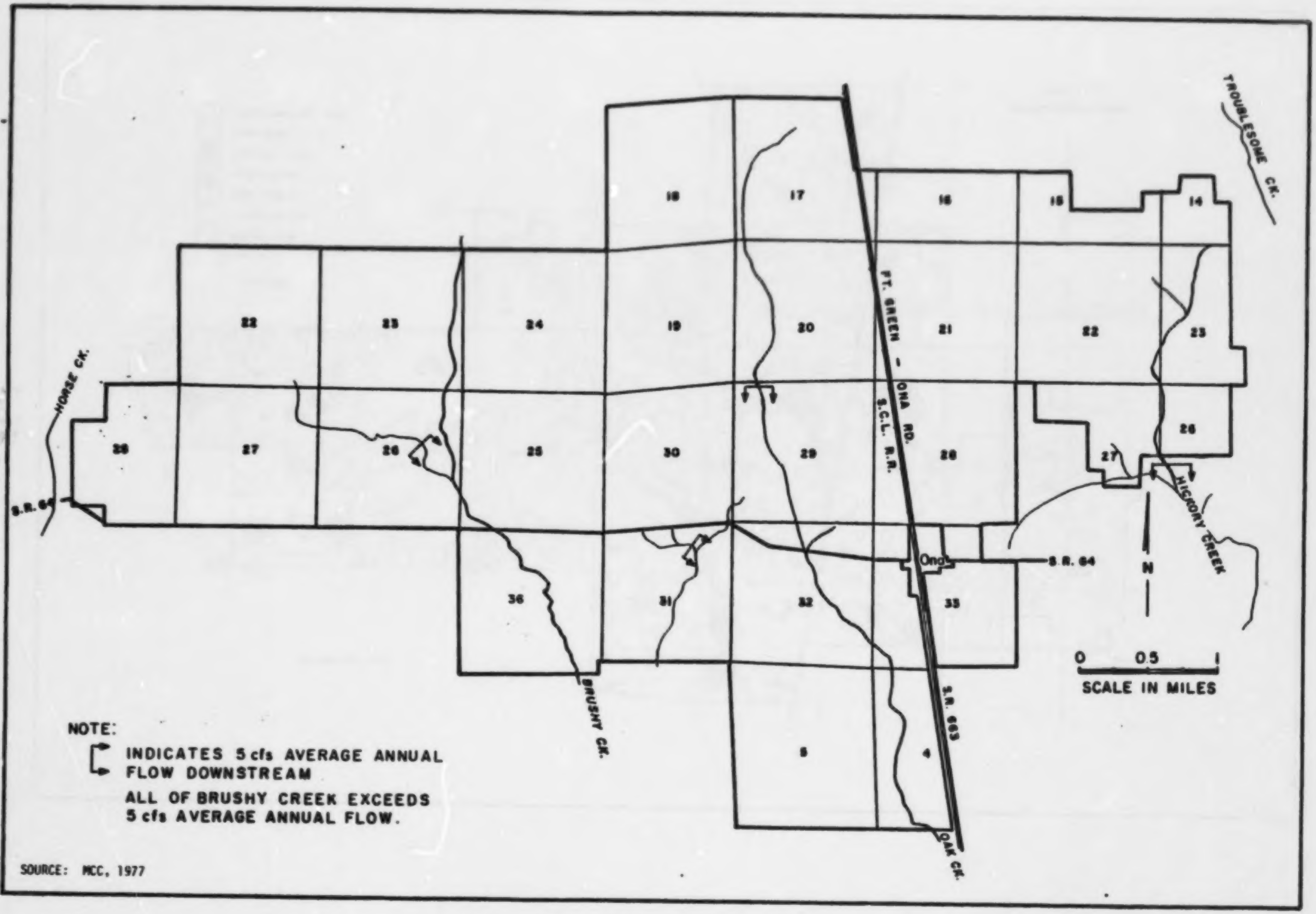
[c] Represents approximate time period when reclamation is to begin. Length of time required for successful reclamation will depend on type and location of reclaimed wetland.


N
HILLSBOROUGH CO.
MANATEE CO.
POLK CO
HARDEE CO
MISSISSIPPI CHEMICAL CORPORATION PROPERTY SITE
9
11
10
21
MANATEE COUNTY
HARDEE CO.
DESOTO CO
HARDEE COUNTY
HIGHLANDS COUNTY
MANATEE COUNTY
SARASOTA CO.
DESOTO CO
SARASOTA COUNTY
DESOTO CO.
CHARLOTTE CO.

SOURCE: MCC, 1977

Reproduced from best available copy.

Figure II-1. Location Map.


TROUBLESOME CK.
HICKORY CREEK
HORSE CK.
BRUSHY CK.
OAK CK.
FT. GREEN - ONA RD.
S.C.L. R.R.
S.R. 663
S.R. 64
S.R. 64
Ona
N
0
0.5
1
SCALE IN MILES
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
36
22
23
26
27
28
4
5

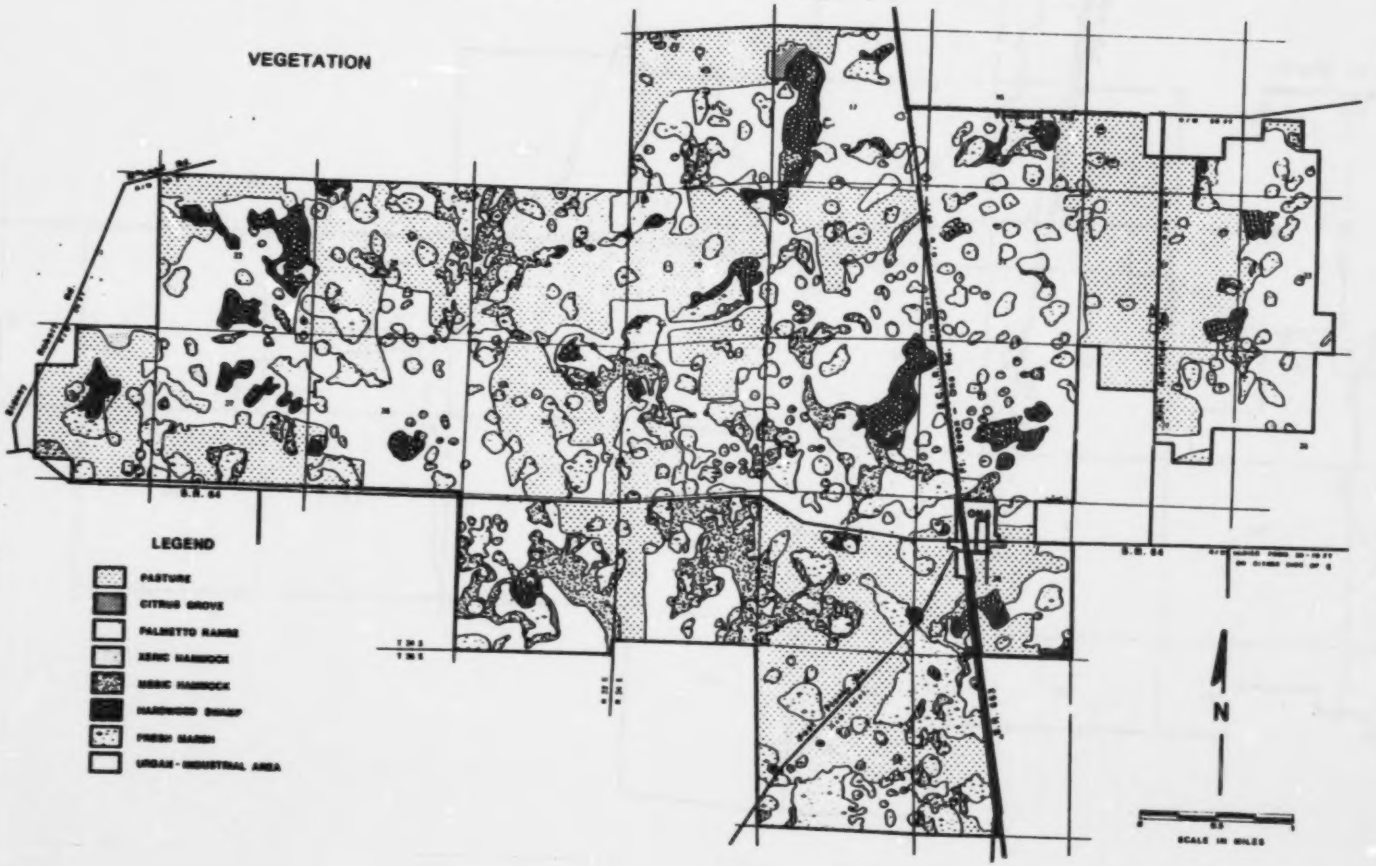
NOTE:

INDICATES 5 cfs AVERAGE ANNUAL FLOW DOWNSTREAM

ALL OF BRUSHY CREEK EXCEEDS 5 cfs AVERAGE ANNUAL FLOW.

SOURCE: MCC, 1977

Figure II-2. MCC Property Drainage.


VEGETATION
LEGEND
PASTURE
CITRUS GROVE
PALMETTO RANGE
XERIC HAMMOCK
MESIC HAMMOCK
HARDWOOD SWAMP
FRESH MARSH
URBAN-INDUSTRIAL AREA
S.R. 64
N
SCALE IN MILES

SOURCE: MCC, 1977

Figure II-3. Vegetation Map of MCC Property.

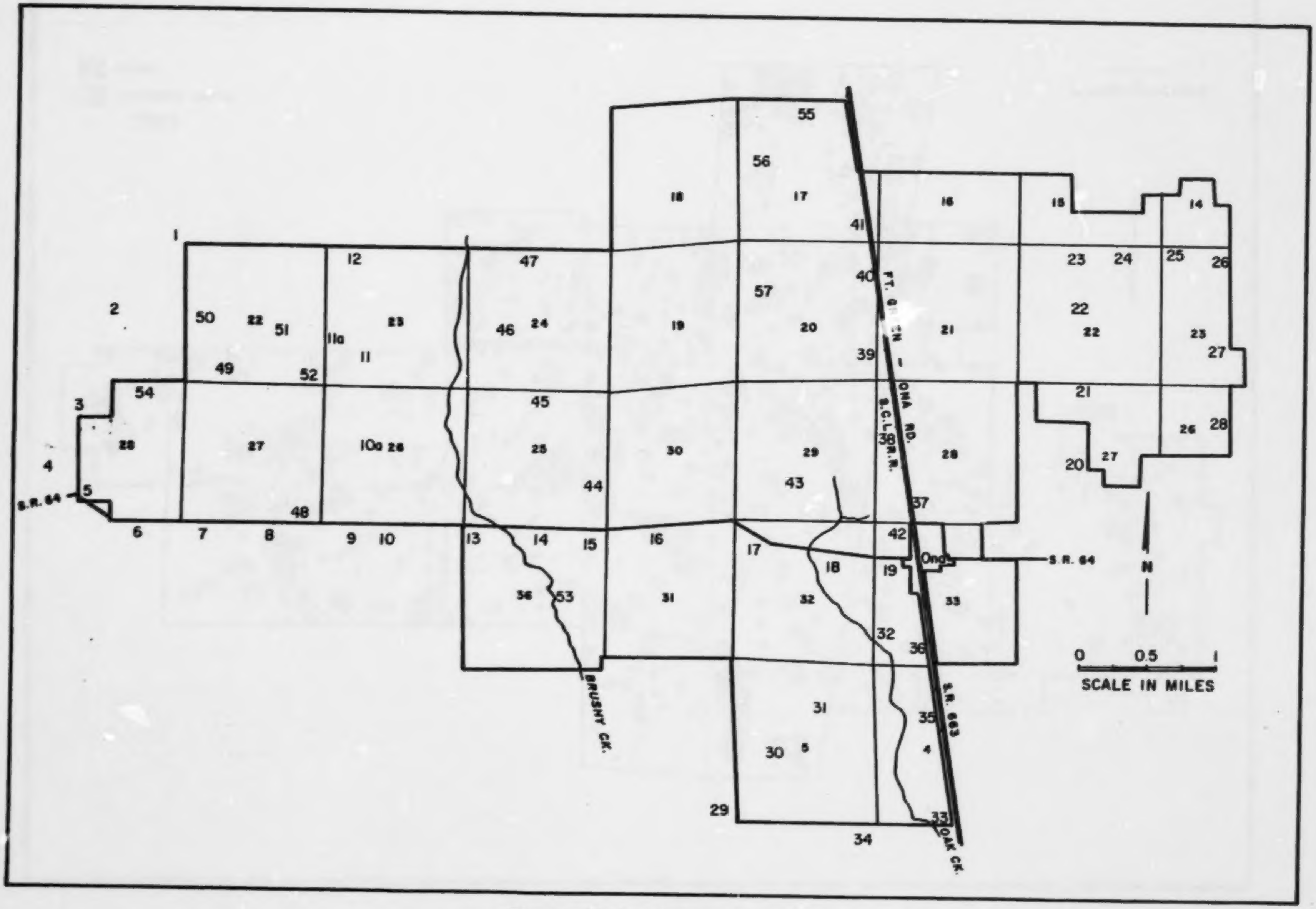
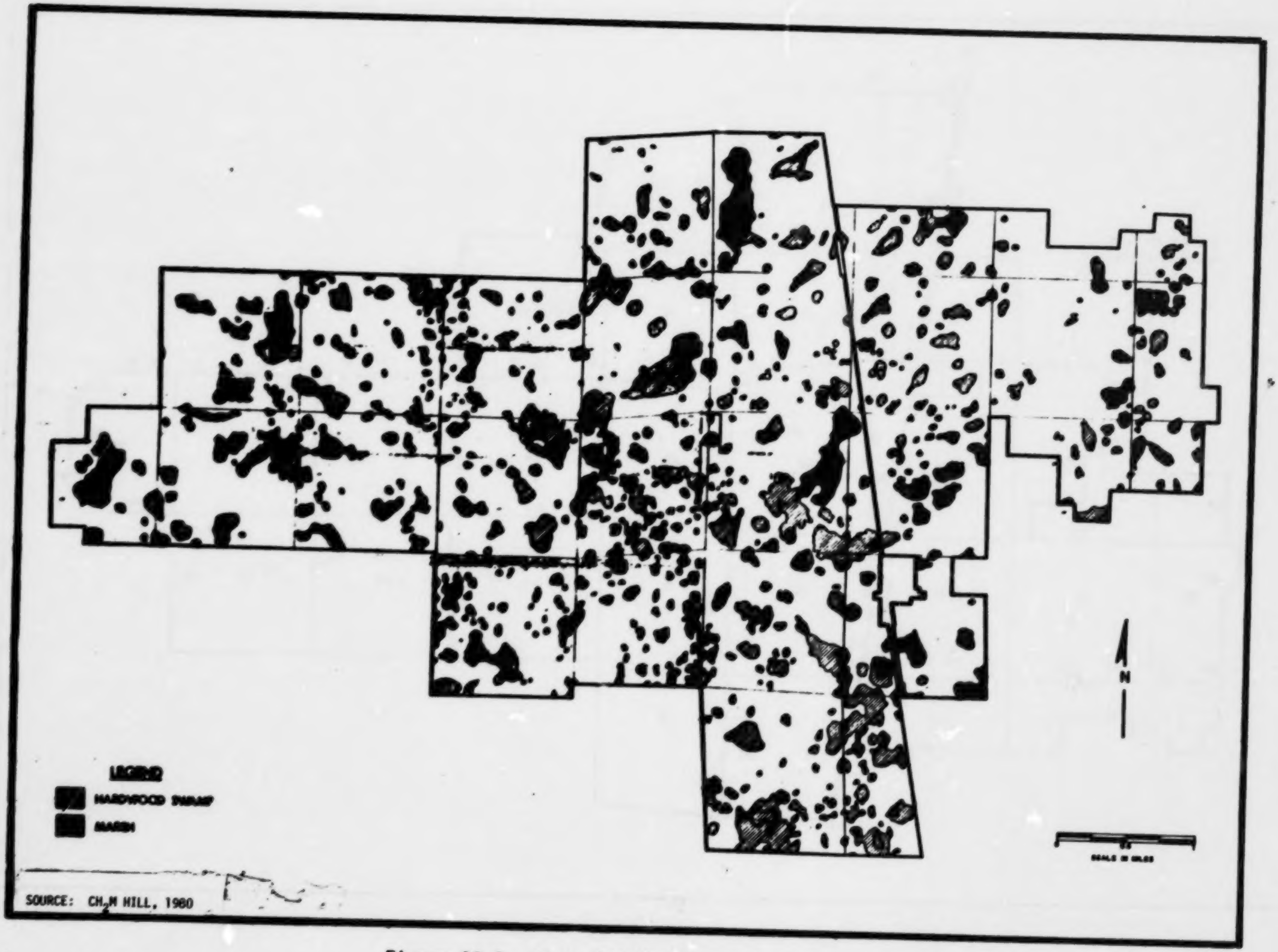

FT. GREEN - ONA RD.
S.C.L. R.R.
S.R. 663
S.R. 64
S.R. 64
Ona
BRUSHY CK.
OAK CK.
N
0 0.5 1
SCALE IN MILES

Figure II-4. Avian Census Map.


LEGEND
HARDWOOD SWAMP
MARSH
N
SCALE IN MILES

SOURCE: CH$_2$M HILL, 1980

Figure II-5. Map of Wetlands on the Site.

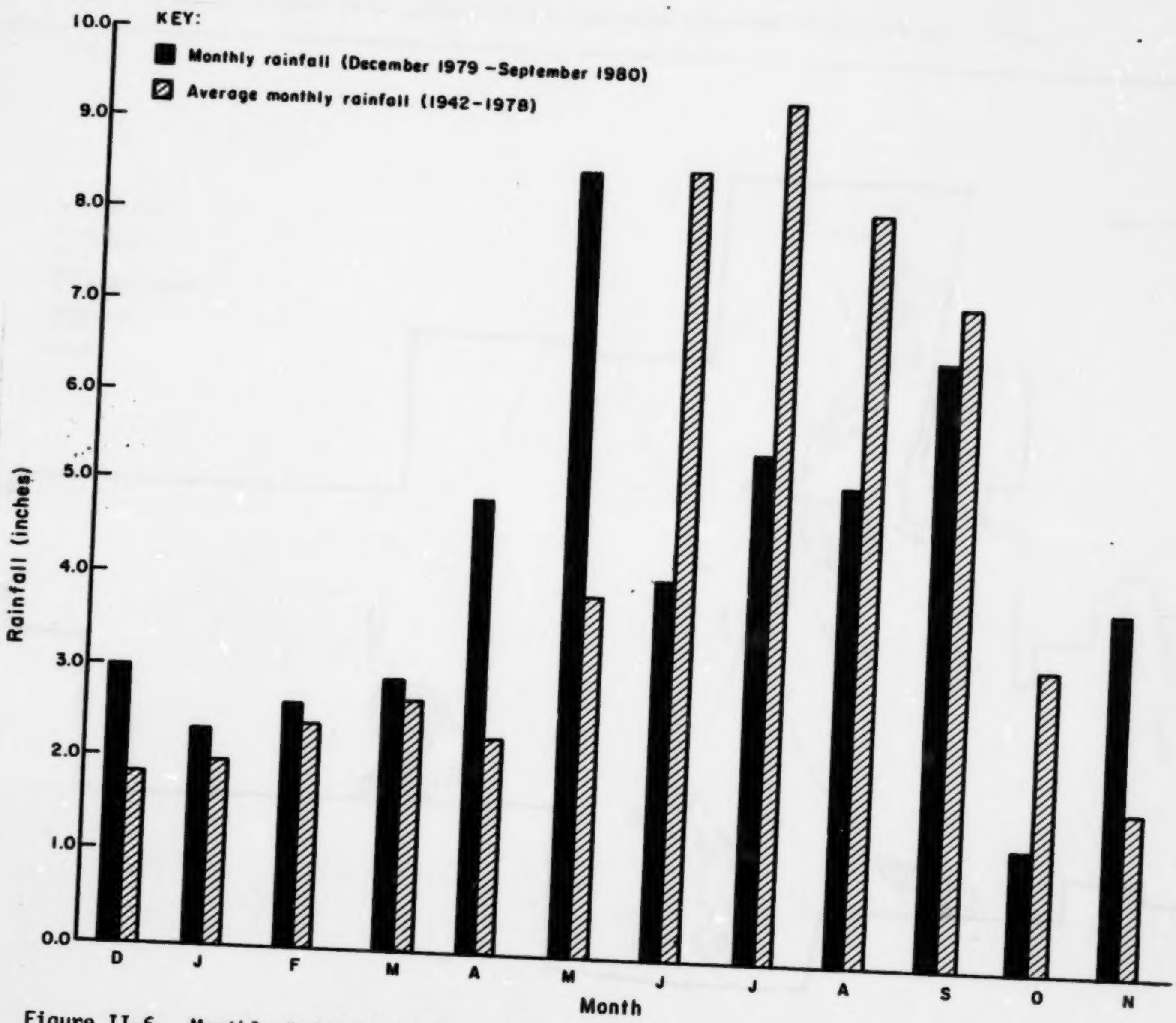


Figure II-6. Monthly Rainfall Near Ona, Florida (Period, December 1979 - September 1980, Compared to 36-Year Average Monthly Rainfall).

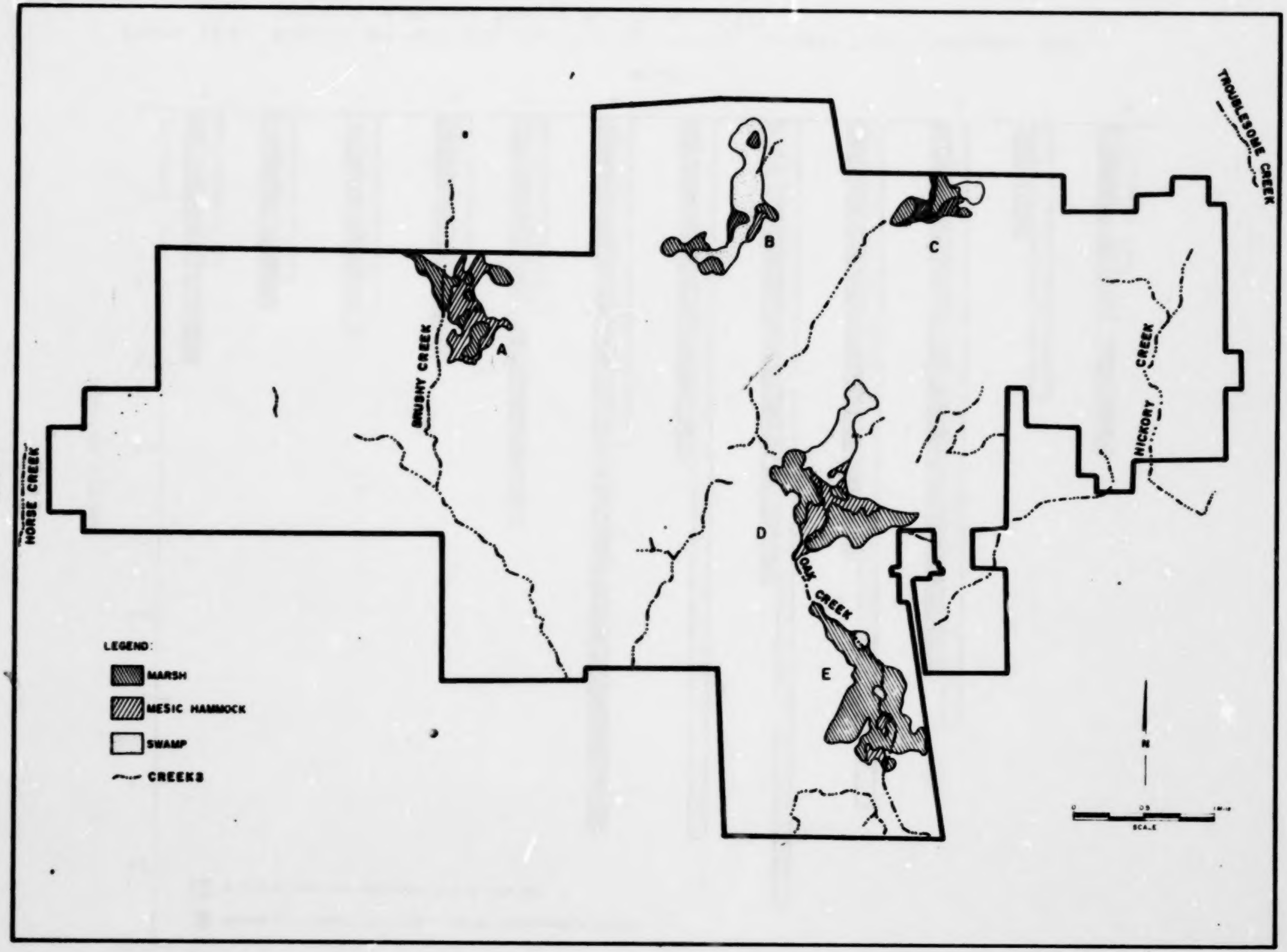

TROUBLESOME CREEK
HICKORY CREEK
BRUSHY CREEK
OAK CREEK
HORSE CREEK
A
B
C
D
E
LEGEND:
MARSH
MESIC HAMMOCK
SWAMP
CREEKS
N
0
0.5
1 Mile
SCALE

Figure II-7. Functionally Important Wetlands Systems on MCC Property.

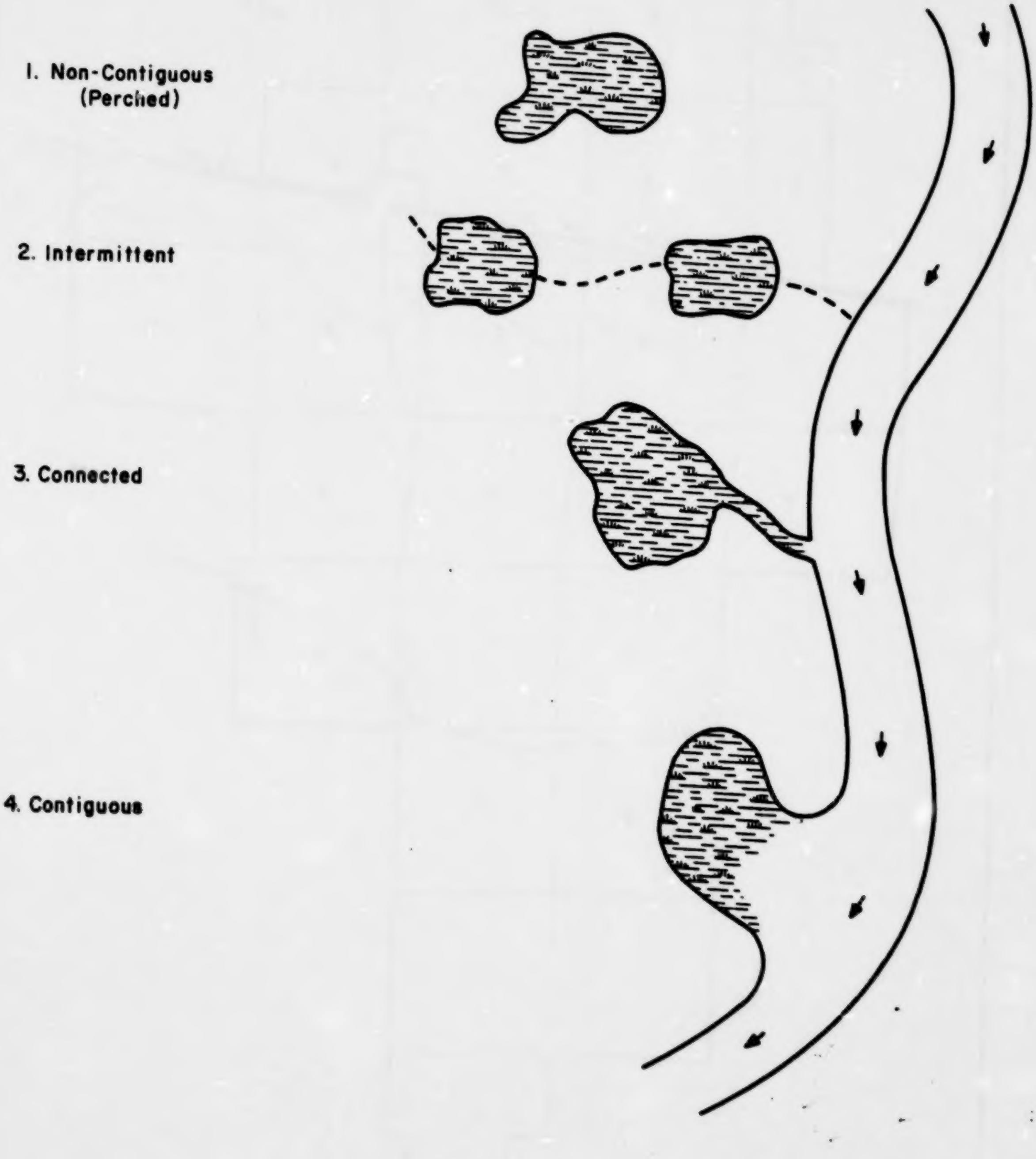

1. Non-Contiguous (Perched)
2. Intermittent
3. Connected
4. Contiguous

Figure II-8. Wetlands Contiguity Diagram.

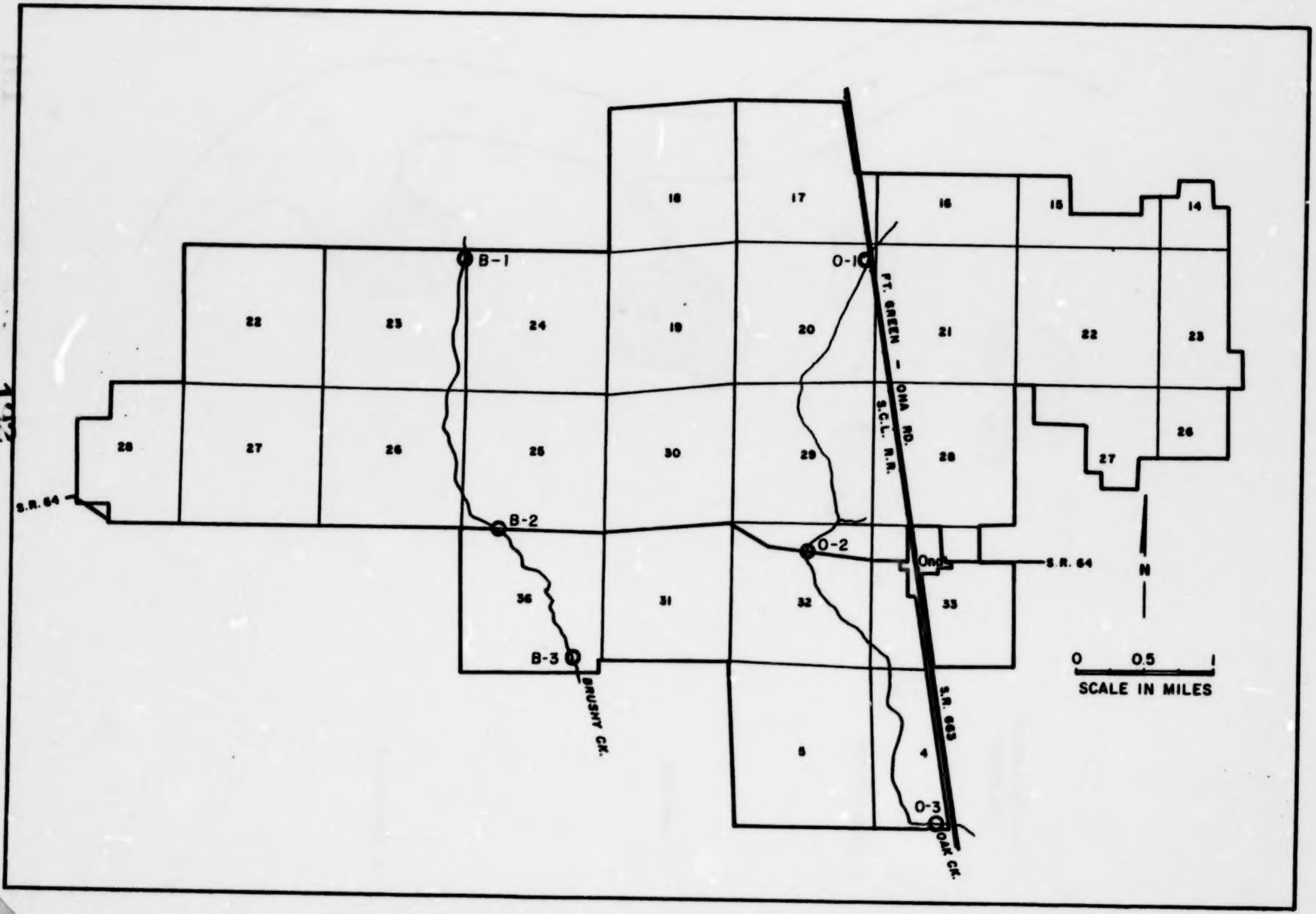

18
17
16
15
14
B-1
O-1
FT. GREEN – ONA RD.
S.C.L. R.R.
22
23
24
19
20
21
22
23
28
27
26
25
30
29
28
27
26
S.R. 64
B-2
O-2
Ona
S.R. 64
N
36
31
32
33
B-3
0
0.5
1
SCALE IN MILES
BRUSHY CK.
S.R. 663
5
4
O-3
OAK CK.

Figure II-9. Aquatic Sampling Stations on MCC Site.

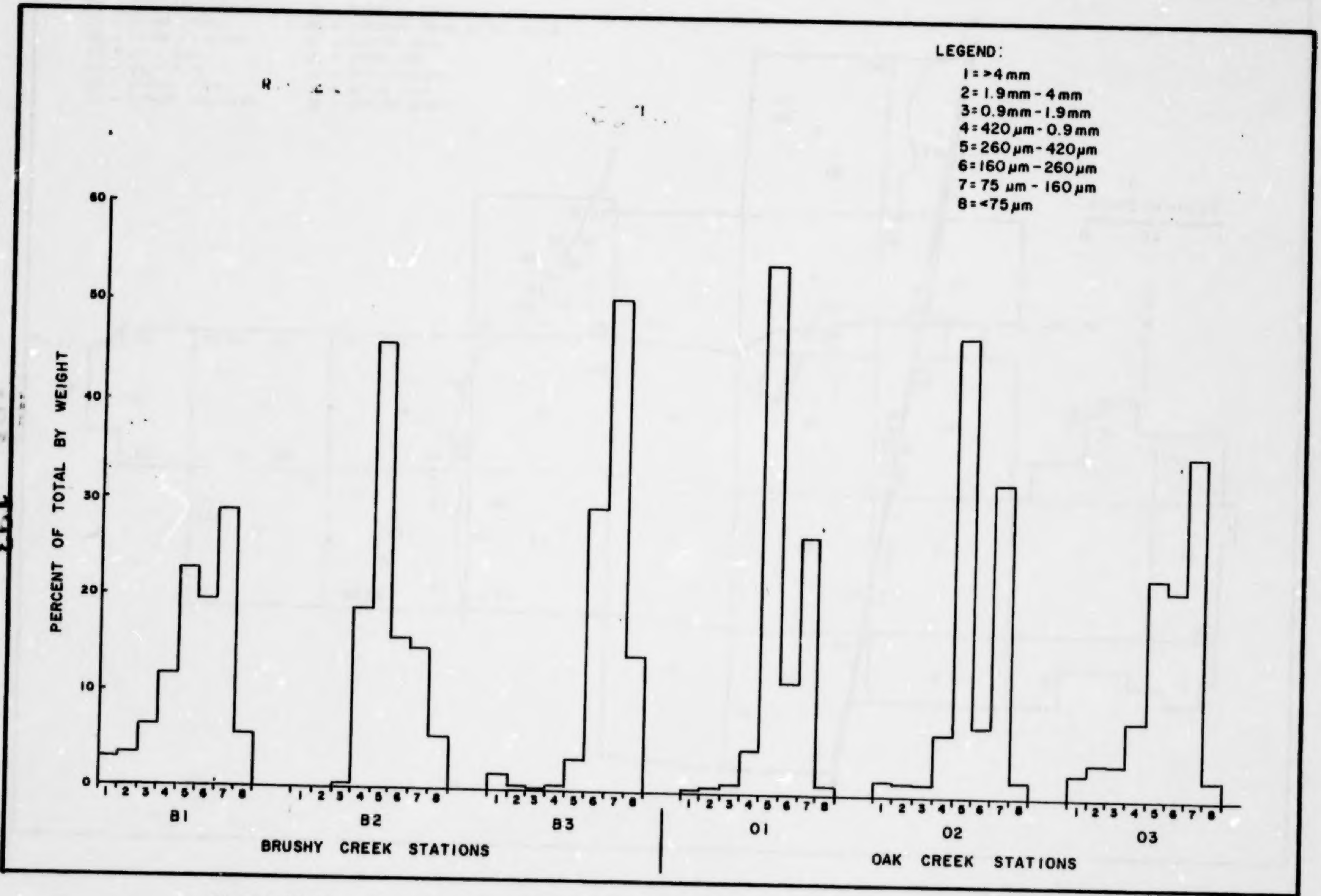
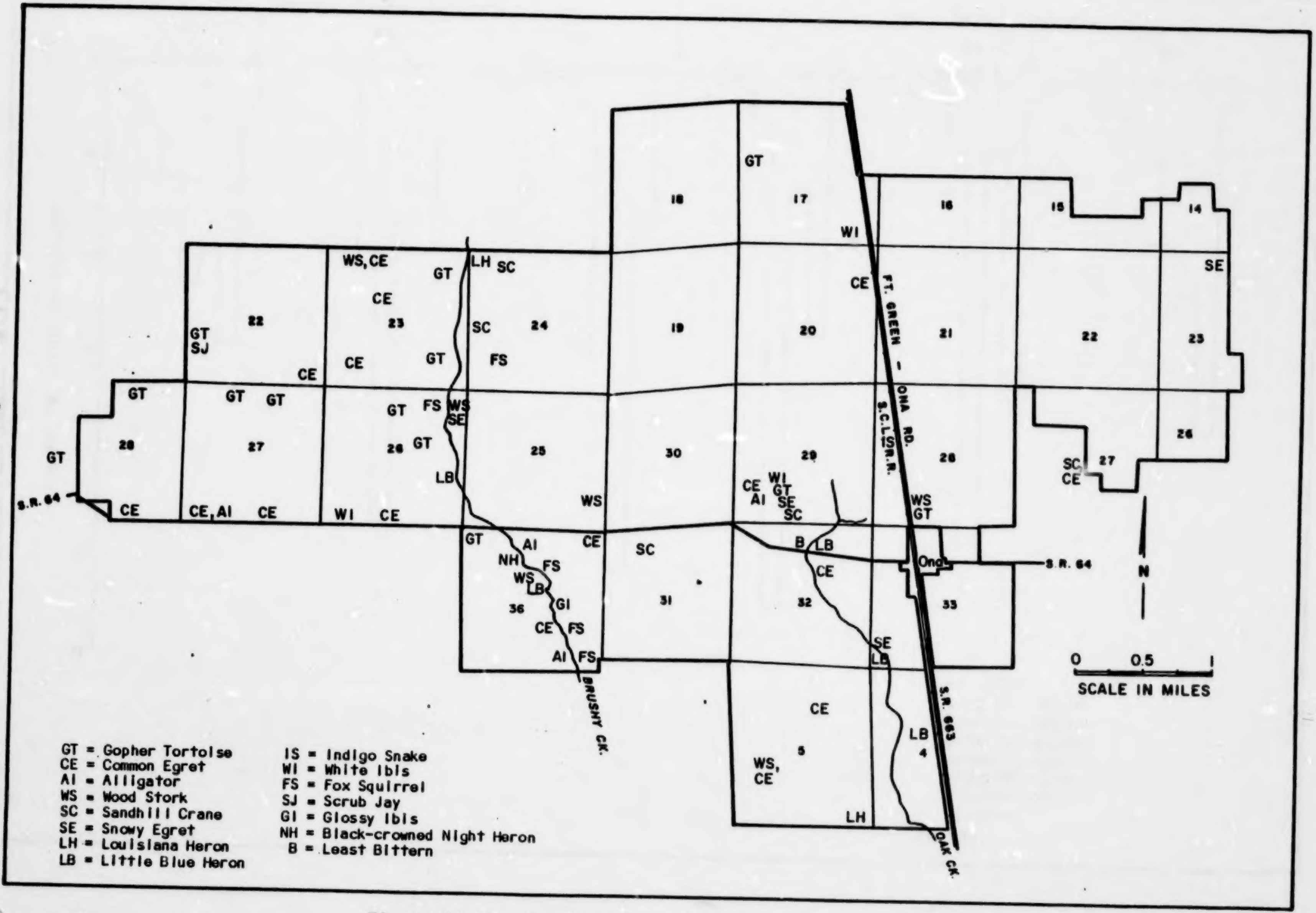
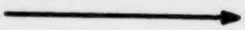


Figure II-10. Particle Size Distribution of Stream Sediments on MCC Property, 1980.

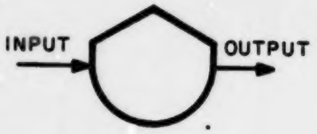


GT = Gopher Tortoise
CE = Common Egret
AI = Alligator
WS = Wood Stork
SC = Sandhill Crane
SE = Snowy Egret
LH = Louisiana Heron
LB = Little Blue Heron
IS = Indigo Snake
WI = White Ibis
FS = Fox Squirrel
SJ = Scrub Jay
GI = Glossy Ibis
NH = Black-crowned Night Heron
B = Least Bittern
FT. GREEN - ONA RD.
S.C.L. R.R.
S.R. 64
S.R. 663
BRUSHY CK.
OAK CK.
Ona
N
0
0.5
1
SCALE IN MILES
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
36
4
5
GT
SJ
CE
WS, CE
LH
SC
FS
WS
SE
LB
WI
AI
NH
GI
B
IS

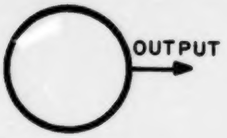
Figure II-11. Species of Special Concern Observed on the Site.



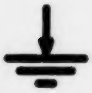
Flow of materials or energy in direction indicated by arrow.


INPUT
OUTPUT

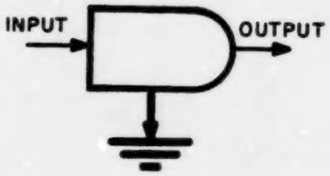
Storage of materials or energy



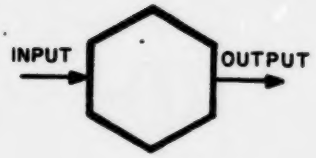
Source of energy or materials located outside of the system.



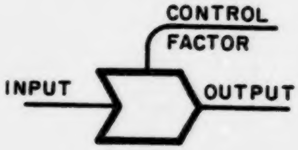
Heat sink. All processes involving work result in a loss of heat according to the second law of thermodynamics. (Heat sinks are left off many processes for simplicity.)


INPUT
OUTPUT

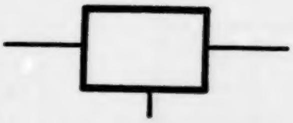
Plant population.


INPUT
OUTPUT

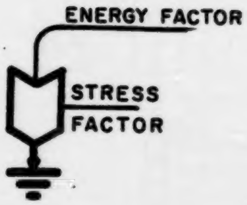
Self maintaining consumer population in which work is done to process energy or materials.


CONTROL
FACTOR
INPUT
OUTPUT

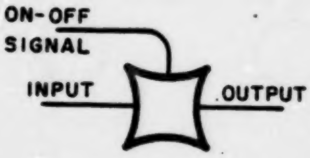
Work gate in which a flow of energy (control factor) makes possible another flow of energy or materials (input-output). Used to show the multiplier interaction of two system components. With a (-) symbol, this may involve a reduction or drag on a flow.



Used in conjunction with a work gate to indicate pumping action, e.g., flow of constituents dissolved in a stream.


ENERGY FACTOR
STRESS
FACTOR

Stress symbol, used to indicate effect of an environmental factor which drains energy from the system.


ON-OFF
SIGNAL
INPUT
OUTPUT

Switch, used to indicate an on-off condition. For example,.if soil moisture decreases below a particular threshold level, then fire is likely to occur.

Figure II-12. Description of Symbols Used in Ecosystems Diagrams.

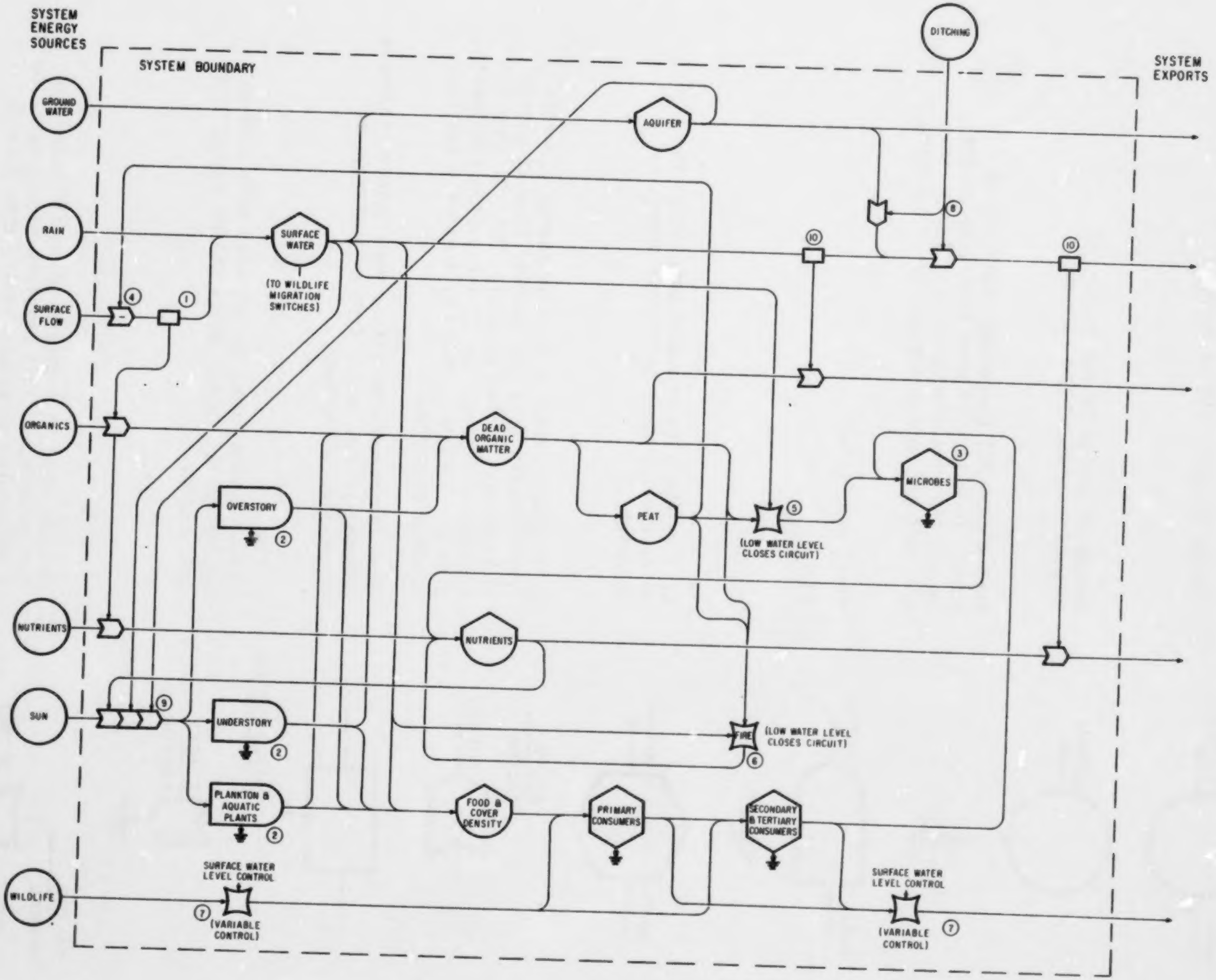

SYSTEM ENERGY SOURCES
SYSTEM BOUNDARY
SYSTEM EXPORTS
GROUND WATER
RAIN
SURFACE FLOW
ORGANICS
NUTRIENTS
SUN
WILDLIFE
DITCHING
AQUIFER
SURFACE WATER
(TO WILDLIFE MIGRATION SWITCHES)
DEAD ORGANIC MATTER
OVERSTORY
PEAT
MICROBES
(LOW WATER LEVEL CLOSES CIRCUIT)
NUTRIENTS
UNDERSTORY
FIRE
(LOW WATER LEVEL CLOSES CIRCUIT)
PLANKTON & AQUATIC PLANTS
FOOD & COVER DENSITY
PRIMARY CONSUMERS
SECONDARY & TERTIARY CONSUMERS
SURFACE WATER LEVEL CONTROL
(VARIABLE CONTROL)
SURFACE WATER LEVEL CONTROL
(VARIABLE CONTROL)
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩

Figure II-13. Swamp Ecosystem.

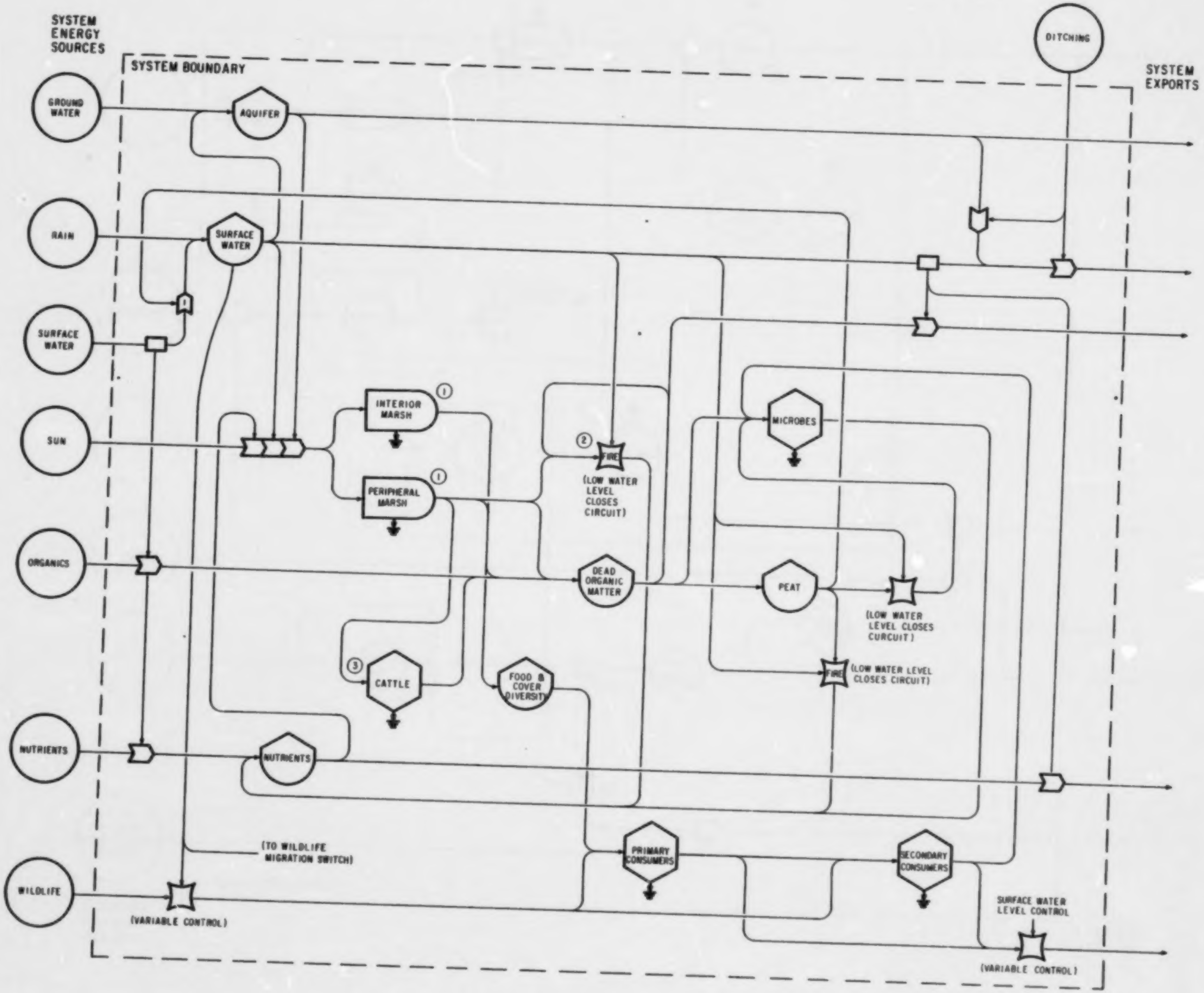

SYSTEM ENERGY SOURCES
SYSTEM BOUNDARY
SYSTEM EXPORTS
DITCHING
GROUND WATER
RAIN
SURFACE WATER
SUN
ORGANICS
NUTRIENTS
WILDLIFE
AQUIFER
SURFACE WATER
INTERIOR MARSH
①
PERIPHERAL MARSH
①
②
FIRE
(LOW WATER LEVEL CLOSES CIRCUIT)
DEAD ORGANIC MATTER
MICROBES
PEAT
(LOW WATER LEVEL CLOSES CURCUIT)
FIRE
(LOW WATER LEVEL CLOSES CIRCUIT)
③
CATTLE
FOOD & COVER DIVERSITY
NUTRIENTS
(TO WILDLIFE MIGRATION SWITCH)
PRIMARY CONSUMERS
SECONDARY CONSUMERS
(VARIABLE CONTROL)
SURFACE WATER LEVEL CONTROL
(VARIABLE CONTROL)

Figure II-14. Marsh Ecosystem.

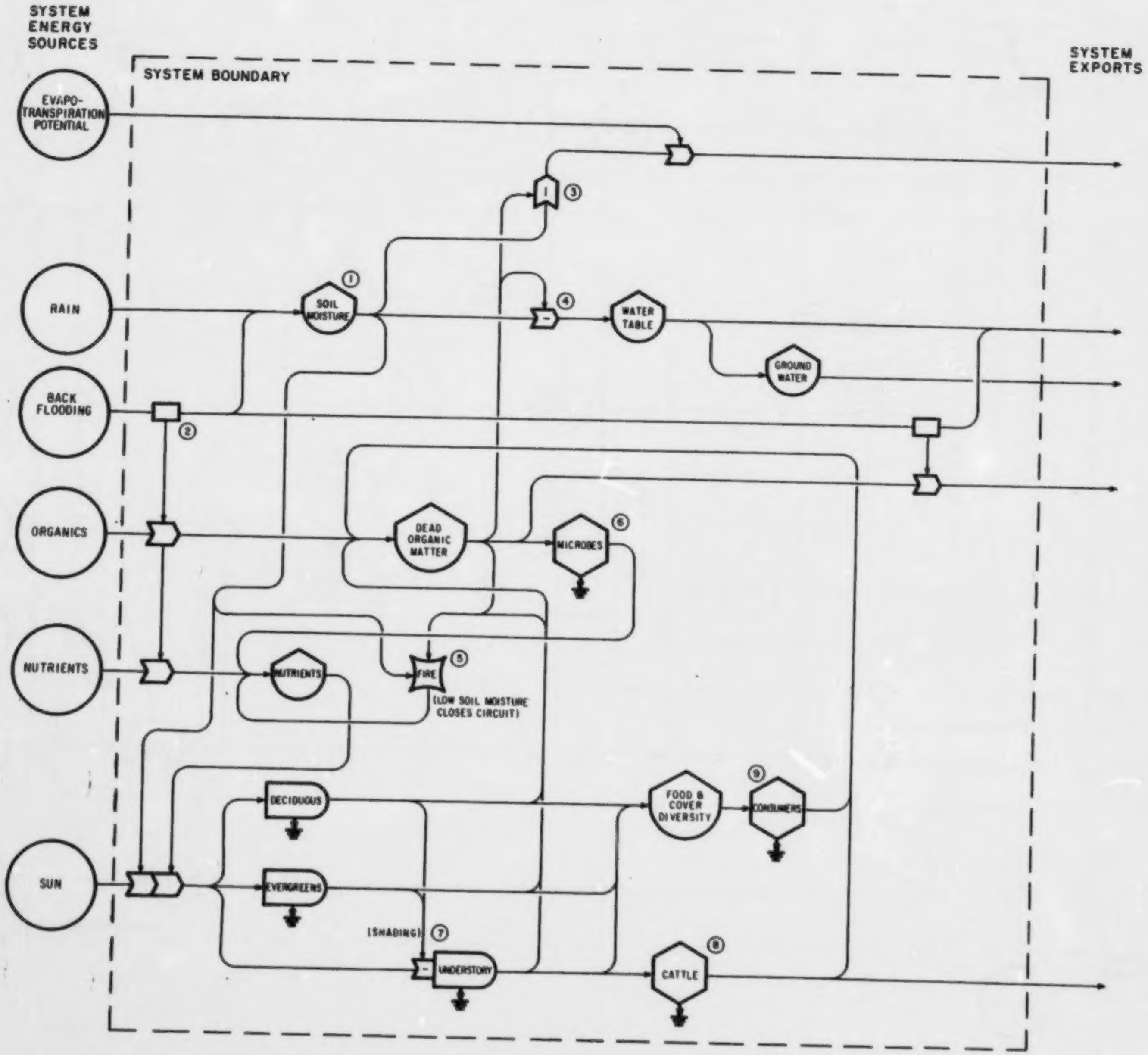

SYSTEM ENERGY SOURCES
SYSTEM BOUNDARY
SYSTEM EXPORTS
EVAPO-TRANSPIRATION POTENTIAL
RAIN
BACK FLOODING
ORGANICS
NUTRIENTS
SUN
①
SOIL MOISTURE
②
③
④
WATER TABLE
GROUND WATER
DEAD ORGANIC MATTER
⑥
MICROBES
NUTRIENTS
⑤
FIRE
(LOW SOIL MOISTURE CLOSES CIRCUIT)
DECIDUOUS
EVERGREENS
(SHADING)
⑦
UNDERSTORY
FOOD & COVER DIVERSITY
⑨
CONSUMERS
⑧
CATTLE

Figure II-15. Mesic Hammock Ecosystem.

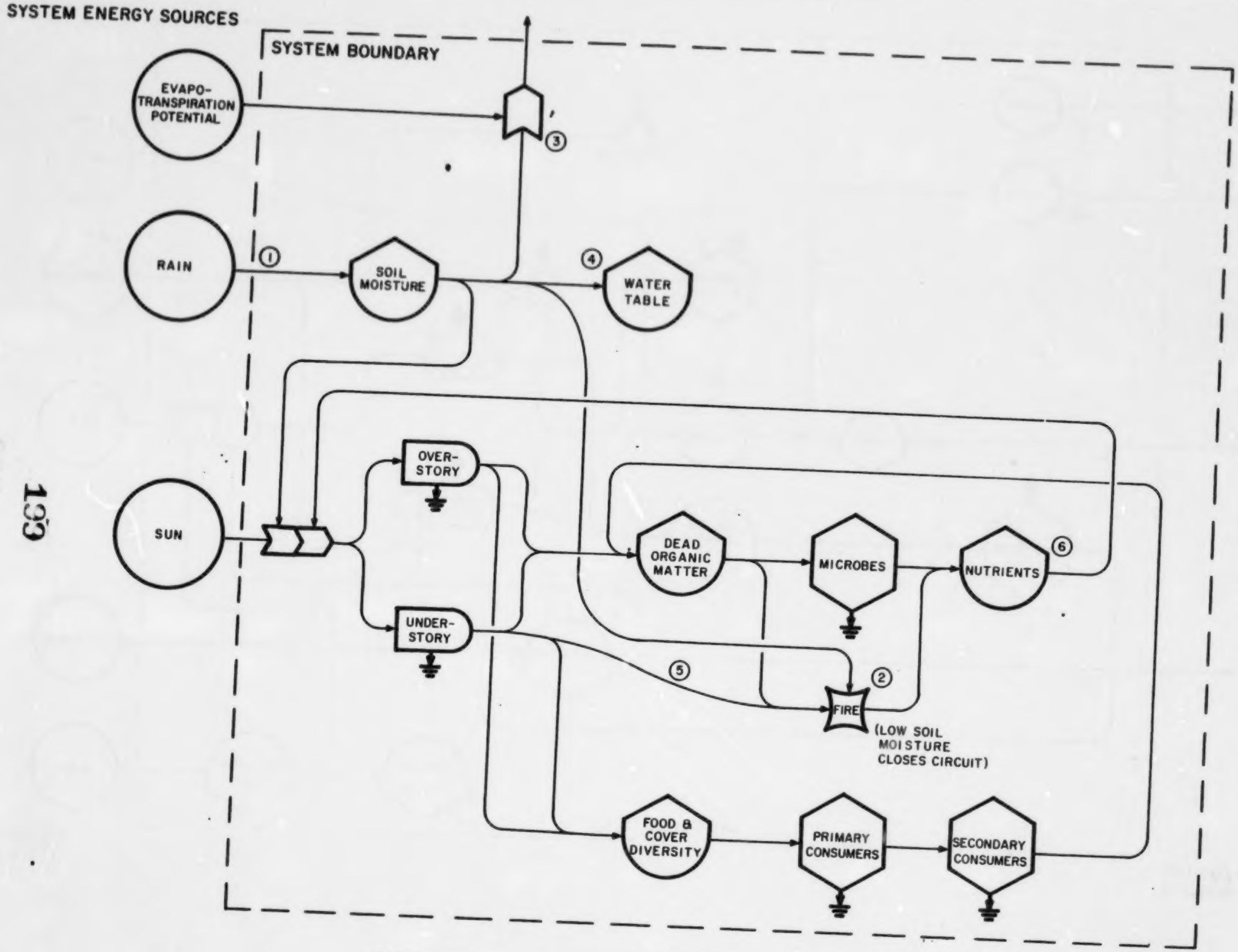

SYSTEM ENERGY SOURCES
SYSTEM BOUNDARY
EVAPO-TRANSPIRATION POTENTIAL
RAIN
SUN
①
SOIL MOISTURE
③
④
WATER TABLE
OVER-STORY
UNDER-STORY
DEAD ORGANIC MATTER
MICROBES
NUTRIENTS
⑥
⑤
②
FIRE
(LOW SOIL MOISTURE CLOSES CIRCUIT)
FOOD & COVER DIVERSITY
PRIMARY CONSUMERS
SECONDARY CONSUMERS

Figure II-16. Xeric Hammock/Palmetto Range Ecosystem.

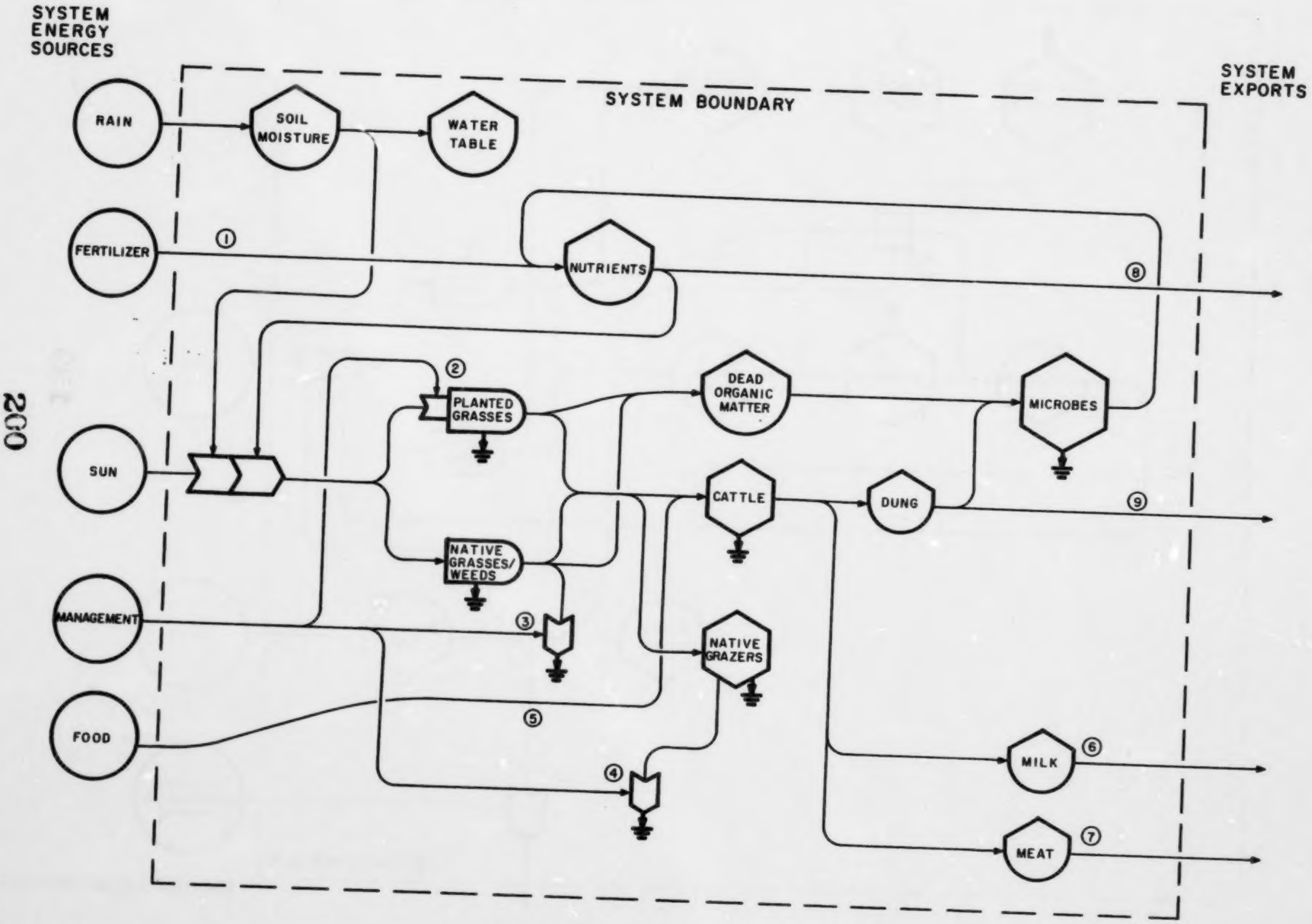
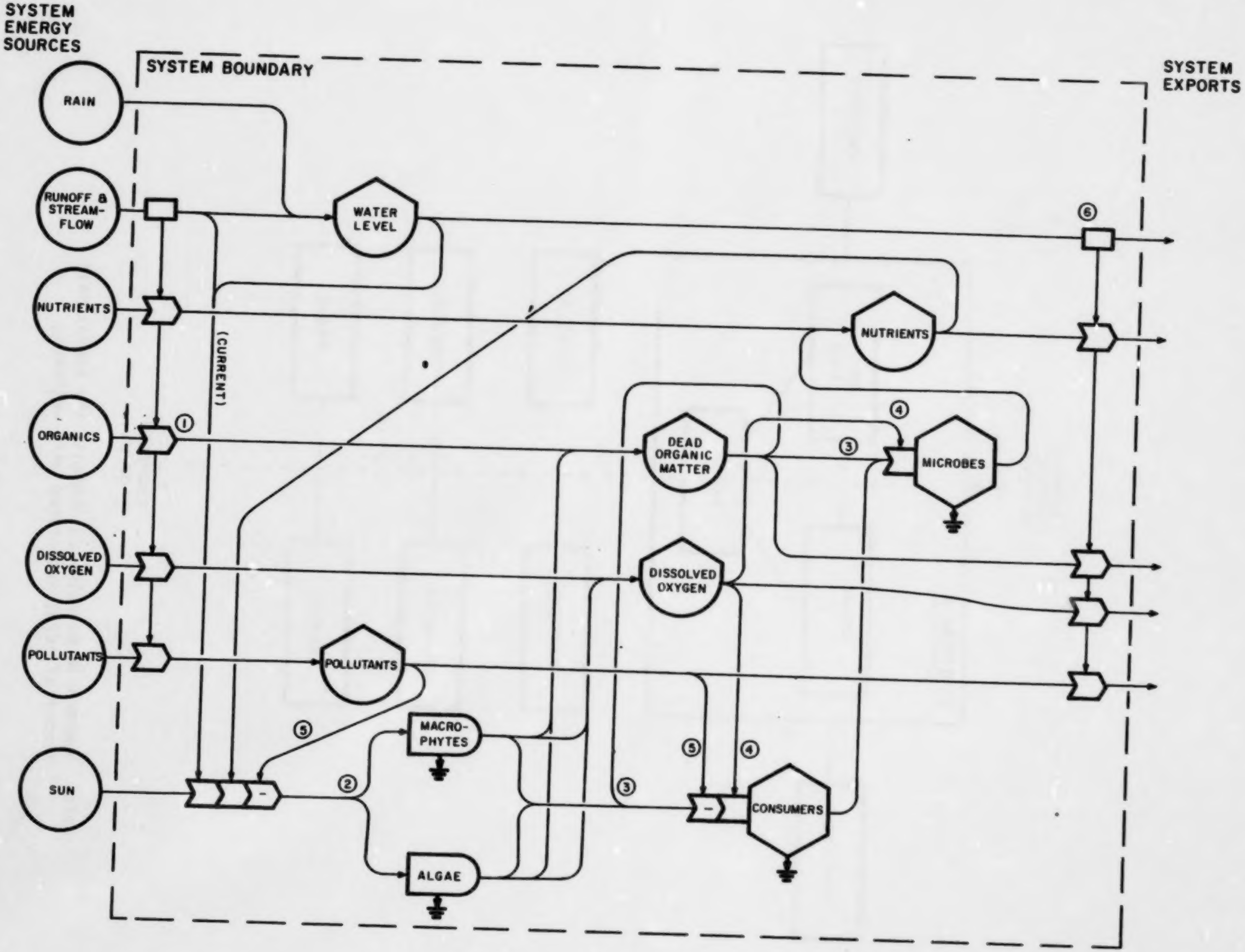
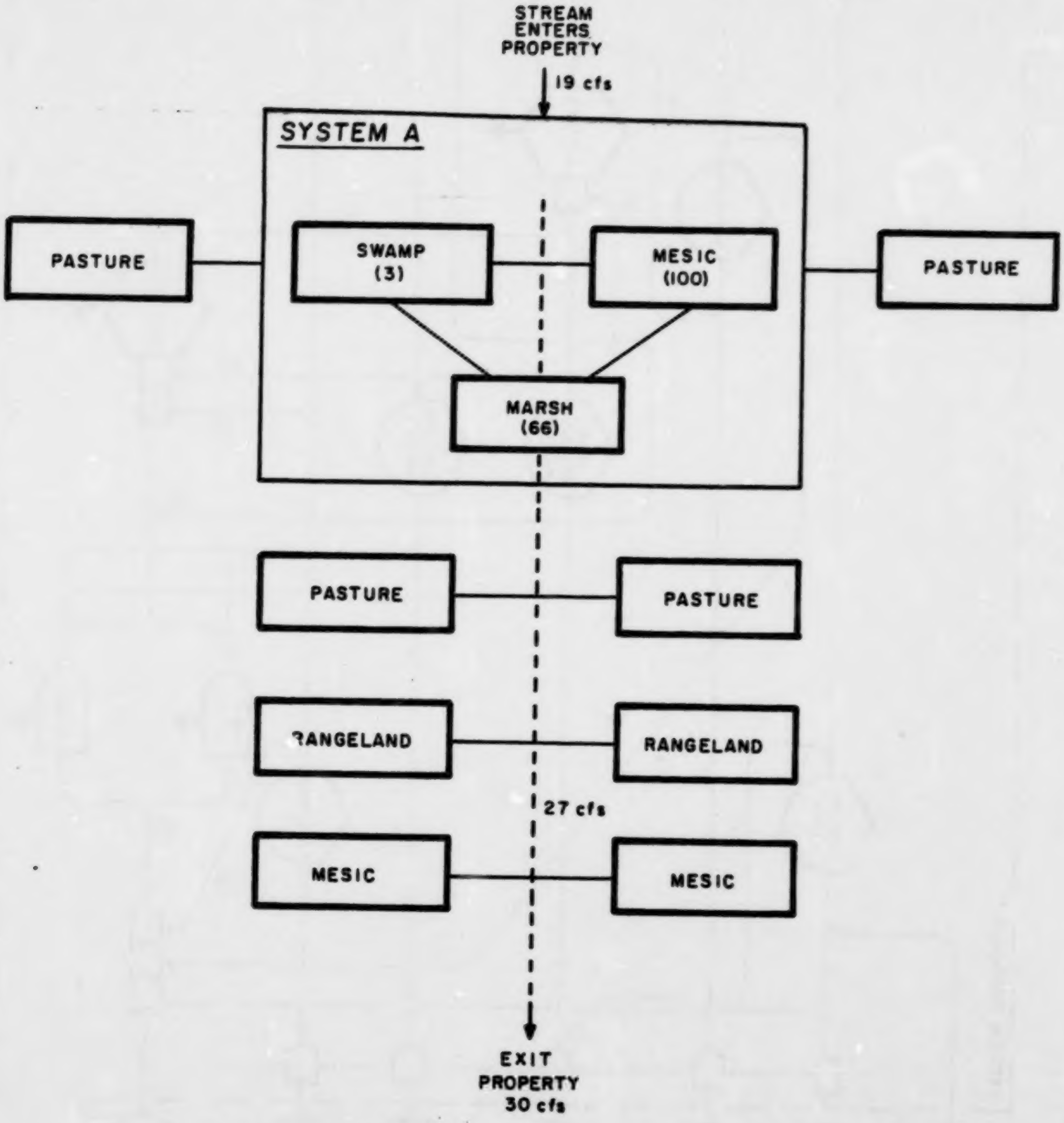

SYSTEM ENERGY SOURCES
SYSTEM BOUNDARY
SYSTEM EXPORTS
RAIN
FERTILIZER
SUN
MANAGEMENT
FOOD
SOIL MOISTURE
WATER TABLE
NUTRIENTS
PLANTED GRASSES
NATIVE GRASSES/ WEEDS
DEAD ORGANIC MATTER
CATTLE
NATIVE GRAZERS
DUNG
MICROBES
MILK
MEAT
①
②
③
④
⑤
⑥
⑦
⑧
⑨

Figure II-17. Pasture Land Ecosystem.



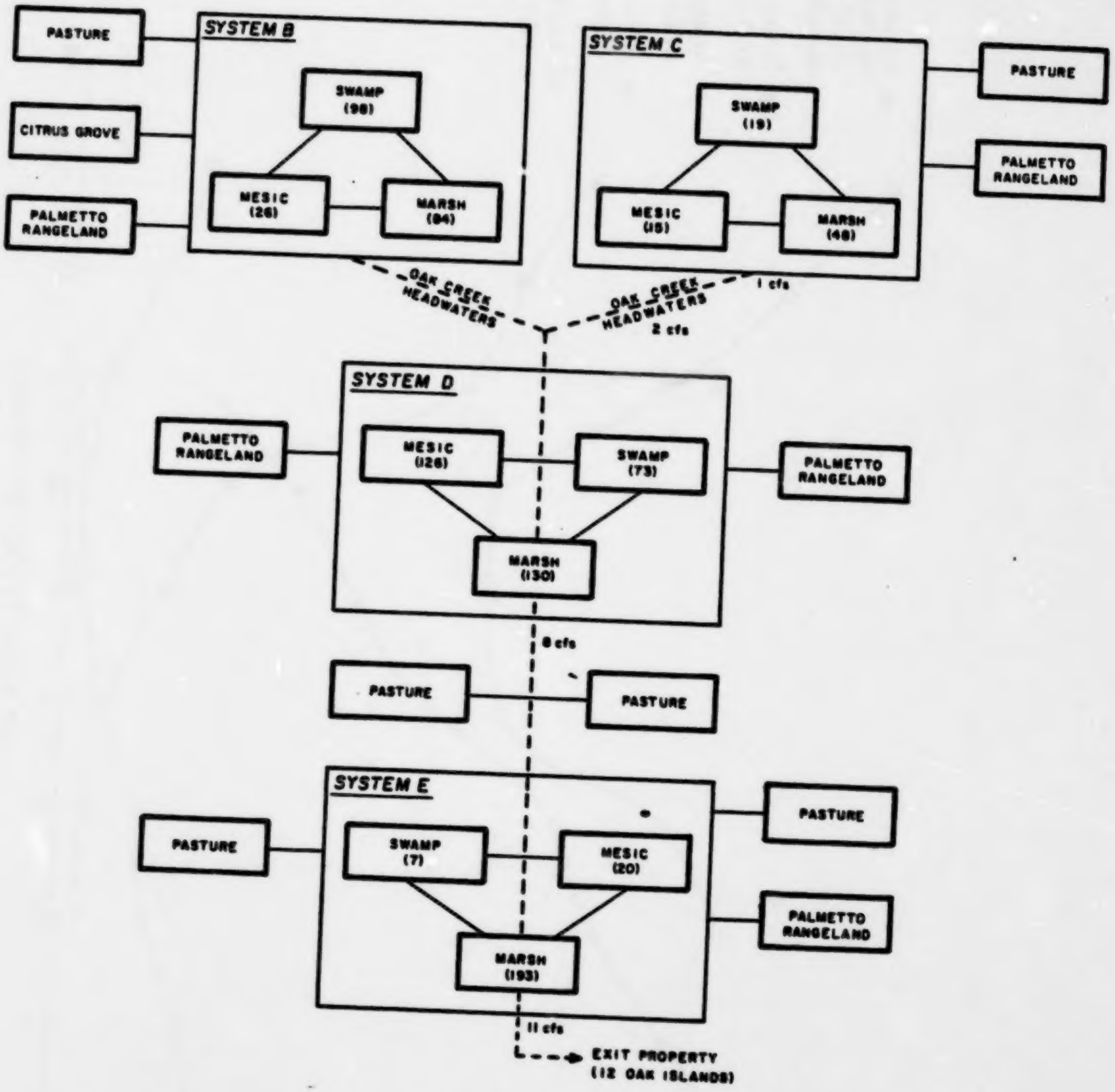
SYSTEM ENERGY SOURCES
SYSTEM BOUNDARY
SYSTEM EXPORTS
RAIN
RUNOFF & STREAM-FLOW
NUTRIENTS
ORGANICS
DISSOLVED OXYGEN
POLLUTANTS
SUN
(CURRENT)
WATER LEVEL
NUTRIENTS
DEAD ORGANIC MATTER
MICROBES
DISSOLVED OXYGEN
POLLUTANTS
MACRO-PHYTES
ALGAE
CONSUMERS
①
②
③
④
⑤
⑥
-

Figure II-18. Creek Ecosystem.


STREAM ENTERS PROPERTY
19 cfs
SYSTEM A
PASTURE
SWAMP (3)
MESIC (100)
PASTURE
MARSH (66)
PASTURE
PASTURE
RANGELAND
RANGELAND
27 cfs
MESIC
MESIC
EXIT PROPERTY 30 cfs

Note: Numbers in parentheses indicate the approximate number of acres associated with wetlands.

Figure II-19. Systems Associated with Brushy Creek.


PASTURE
CITRUS GROVE
PALMETTO RANGELAND
SYSTEM B
SWAMP (98)
MESIC (26)
MARSH (84)
SYSTEM C
SWAMP (19)
MESIC (15)
MARSH (48)
PASTURE
PALMETTO RANGELAND
OAK CREEK HEADWATERS
OAK CREEK HEADWATERS
1 cfs
2 cfs
SYSTEM D
PALMETTO RANGELAND
MESIC (126)
SWAMP (73)
MARSH (130)
PALMETTO RANGELAND
8 cfs
PASTURE
PASTURE
SYSTEM E
PASTURE
SWAMP (7)
MESIC (20)
MARSH (193)
PASTURE
PALMETTO RANGELAND
11 cfs
EXIT PROPERTY (12 OAK ISLANDS)

Note: Numbers in parentheses indicate the approximate number of acres associated with wetlands.

Figure II-20. Systems Associated with Oak Creek.

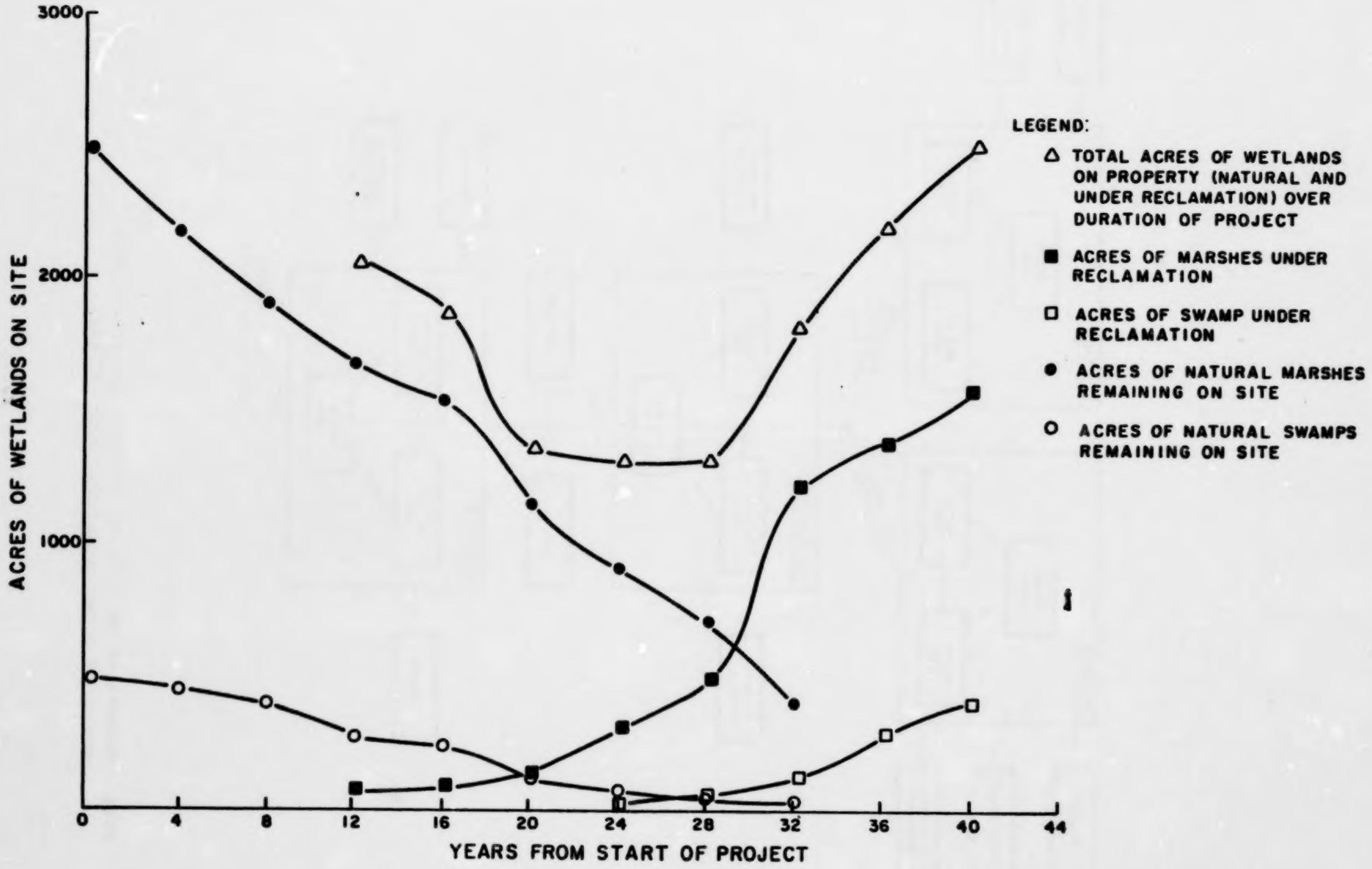


Figure II-21. Wetlands Losses and Replacement Over the MCC Project Life.

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# TECHNICAL SUPPORT DOCUMENT III

# AIR RESOURCES

# III AIR RESOURCES

## 1.0 CLIMATOLOGY

A complete description of climatology in the vicinty of MCC's Hardee County mine site is provided in Section 3.4.1 of the DEIS.

## 2.0 EXISTING AMBIENT AIR QUALITY

A complete description of existing ambient air quality in the vicinity of MCC's Hardee County mine site is provided in Section 3.4.2.1 of the DEIS.

# 3.0 ENVIRONMENTAL IMPACTS

## 3.1 ROCK DRYER AT ONA (PROPOSED BY MCC)

Mississippi Chemical Corporation (MCC) is proposing to construct and operate a phosphate rock mine and processing complex in Hardee County, Florida (see Figure III-1). The processing complex would consist of a beneficiation plant, a 450-ton per hour (design capacity) rock dryer, and all associated storage and transfer facilities. The beneficiation plant operation is a totally wet process. Therefore, the only significant air pollutant emissions generated would be from the operation of a small boiler. Due to the wet process, fugitive emissions are expected to have minimal impact. In the rock drying process, emissions would be generated by the rock dryer itself and by another small boiler. Other operations with potential air pollution emissions are the dry rock silo storage and transfer operations. The dry rock loadout operation would be controlled by wet scrubbers and the dry rock conveyors and the transfer points would be completely enclosed.

The project, as proposed, would be operated in full conformance with all applicable air pollution control rules and regulations.

### 3.1.1 Methodology

Estimated atmospheric emissions from the proposed MCC complex are great enough to require assessment of compliance with prevention of significant deterioration (PSD) increments for sulfur dioxide ($SO_2$) and particulate matter (PM), and with National Ambient Air Quality Standards (NAAQS). Compliance with these requirements has been assessed through the use of USEPA-approved computer modeling techniques. Compliance with Ambient Air Quality Standards (AAQS), national and State of Florida, was assessed by superimposing modeling results on ambient air quality measurement data. The monitoring measurements were used to represent ambient air pollutant background conditions.

The CRSTER model was run on 5 years of hourly meteorological data (1970-1974) recorded at Tampa International Airport by the National Weather Service (NWS) and was used to determine maximum predicted annual concentrations and to identify worst-case 24-hour and 3-hour meteorological conditions for the proposed facility. The maximum short-term impacts were then refined with the PTMTPW model. Both CRSTER and PTMTPW are USEPA-approved computer dispersion models and are described in Environmental Science and Engineering, Inc. (1981a).

The maximum annual average PM concentrations in the MCC area were determined by calculating annual arithmetic average concentrations, converting those values to geometric means and adding annual average monitoring data to the calculated values.

The maximum short-term air quality impacts in the MCC area for all pollutant emissions were determined using CRSTER-defined, worst-case 24-hour and 3-hour meteorology, considering the proposed MCC sources and the existing Hardee County (Wauchula and Zolfo Springs), FPI Manatee, new IMC, and Agrico sources. This included the consideration of any interaction between the proposed and existing sources.

In addition, analyses were made to determine maximum PSD Class II increment consumption in the vicinity of the proposed MCC sources. Three sources were determined to consume increment in the area and interact with the proposed new sources:

- Agrico Chemical Company (AGRICO).
- New Wales Chemical (IMC).
- Florida Power & Light (FPL) - Manatee.

The USEPA Industrial Source Complex (ISC) model, a USEPA-approved computer dispersion model, was used to determine the impact of the proposed MCC complex source on the Tampa total suspended particulate (TSP) and the Pinellas County $SO_2$ nonattainment areas, and the Chassahowitzka PSD Class I area.

The computer dispersion models were run using maximum allowable emission rates for all sources. Emissions from sources with no applicable limiting regulation were calculated at maximum production capacity, reflective of maximum emissions. These analyses included the effects of interaction between pollutants released by the proposed MCC plant and other major sources in the area.

Background ambient concentrations were determined using available data from several monitoring locations in the immediate area of the proposed MCC complex site. Since the proposed MCC complex is to be located in a rather remote area of Hardee County similar to the Hardee County monitoring locations, the maximum pollutant levels recorded by those monitors were used as representative ambient background levels in the air quality analysis.

### 3.1.2 Emissions

The air pollutant-emitting facilities considered are a phosphate rock dryer, two small boilers, fuel combustion in mining equipment, a storage silo facility, dry rock loadout stations, and associated conveying operations. Particulate matter (dust) emissions from the fluid bed dryer and the dry rock silos would be controlled by wet scrubbers. Dust emissions generated by transferring stored rock via conveyor belts to the loadout stations would be controlled by a venturi scrubber or bag collector. The rock dryer design-output is 450 TPH of dry phosphate rock but the total mine output is projected to be 3 million TPY (342.5 TPH). A bank of storage silos would store the phosphate product, which would then be transferred to two dry rock facilities for rail shipment from the mine to port facilities in the Tampa Bay area. Dry rock would then be barged to MCC's Pascagoula fertilizer plant or to other customers.

Dust associated with construction and mining would be controlled by best available control technology (BACT). The estimated emission rate of fugitive dust from construction is 86 tons/year and from mining activities is 299 tons/year as shown in Table III-1 (USEPA, 1980 and USEPA, 1978b). However, this material is preponderently large diameter dust particles that are expected to quickly settle back to the ground, and are not expected to contribute significantly to air pollution at locations distant from the mining site. Therefore, these fugitive emissions, although included in the emissions inventory, were not considered in the dispersion modeling of PM emissions from the proposed project.

BACT for all affected pollutants would be met by the use of appropriate control techniques and established quality control procedures for the operation of the proposed dryer, associated storage and transfer operations. The estimated atmospheric emissions from the above operations are listed in Table III-1.

### 3.1.3 Results

This section presents the expected impacts of the MCC complex on air quality during plant operation only. Pollutant emissions during site preparation and construction would have only a minor short-term effect on air quality. Emissions from mining and transportation activities were also not included in the modeling analyses. These emissions would not, in general, interact significantly with other operational emissions. Also, the effects of mining and transportation emissions on air quality are small in comparison to those given in this section for point sources (the two small boilers, the phosphate rock dryer, and the four scrubbers).

Table III-3 presents the calculated highest, second-highest ground-level $SO_2$ concentrations* (maximum, in the case of annual average) during plant operation, the representative ambient background concentrations, and the State of Florida standards for comparison. The highest, second highest concentrations are given for short-term concentrations because the limits can be exceeded once per year at each receptor. National ambient air quality limits are shown in Table III-4.

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*The highest, second-highest concentration is the largest second-ranked concentration calculated (or measured) at any location in the area. Use of this awkward term is necessitated because the short-term air quality standards can be exceeded once a year (but not twice) before a violation of the standard is deemed to occur.

Although maximum calculated $SO_2$ concentrations are substantially increased over present ambient conditions, calculated concentrations are well below the Florida AAQS. The maximum annual average $SO_2$ concentration is 10 $\mu g/m^3$, determined by summing the maximum calculated and the ambient background concentrations. The highest, second-highest 24-hour and 3-hour concentrations are 110 $\mu g/m^3$ and 315 $\mu g/m^3$, respectively, which also include the background concentrations. These maximum predicted concentrations are 17, 42, and 24 percent of the Florida AAQS, respectively.

In Table III-3 are listed the calculated highest, second-highest ground-level PM concentrations during plant operation, the ambient background concentrations and the State of Florida standards for comparison. The maximum annual PM concentration is 30 $\mu g/m^3$, determined by summing the maximum calculated and background concentrations. This value is 50 percent of the Florida AAQS. The highest, second-highest 24-hour ground-level concentration is 106 $\mu g/m^3$, including the ambient background concentration of 90 $\mu g/m^3$. This level is 71 percent of the national secondary and the state of Florida AAQS.

Only the maximum calculated concentrations from $NO_x$ and CO emissions during plant operation are included in Table III-3. It was assumed that all $NO_x$ emissions would be converted to nitrogen dioxide ($NO_2$). These concentrations are 1 $\mu g/m^3$ for $NO_2$ (annual average) and 3 and 2 $\mu g/m^3$ for CO (1-hour and 8-hour averages, respectively). These concentrations are considered quite conservative since they were developed from the unrefined CRSTER program with the MCC complex as a point source.

Comparison of these values for $NO_2$ and CO with the AAQS indicate that these concentrations are well within compliance. The predicted maximum annual arithmetic mean (average) concentration of 1 $\mu g/m^3$ for $NO_2$ is equal to the PSD significant impact level for Class II areas.

No significant pollutant impact is expected at levels below this value (see Table III-4). Therefore, only a very minor impact is considered likely in the vicinity of the MCC complex due to $NO_x$ emissions.

The predicted maximum concentrations of HC are not listed in Table III-3 because hydrocarbons are reactive and, when emitted, contribute to the formation of ozone ($O_3$) through a series of chemical reactions. Modeling analysis of HC is not required because HC ambient standards exist only as a guide to attain the ozone AAQS where a major HC source is proposed. MCC's proposed complex is not considered a major source of HC (total complex emission rate is 9.7 TPY, most of which is temporary, vs. emission rate of 100 TPY for a major emitting facility).

Currently there are no NAAQS or Florida AAQS for gaseous or particulate fluorides. NSPS for fluorides exist for phosphate chemical processing plants but not for mining or beneficiation plants. State emission limiting standards exist for fluorides emitted from phosphate processing plants, but phosphate rock dryers are explicitly excluded from the standards (FDER, 1979). The state regulations do require that BACT for fluorides be applied to both phosphate rock dryers and beneficiation plants.

Fluoride emissions have been defined and their impacts discussed in more detail in the Central Florida Phosphate Industry Areawide EIS (USEPA, 1978a). The Areawide EIS indicated that the state has designated a fluoride level of 45 parts per million, deposited onto or contained within pasture grasses, as the limit that could be safely ingested by cattle. However, this level does not appear as an ambient air standard in the Florida regulations (FDER, 1979).

Ambient fluoride data have been collected at 14 sites in the general region of the proposed new phosphate rock processing complex. These data included both gaseous and particulate concentrations, and are summarized in Section 3.4.2.1 of the DEIS. The relatively low temperature (230°F) at which phosphate rock is dried does not cause appreciable generation of gaseous fluoride, but it is recognized that relatively small quantities are produced. While the actual emission rate is generally considered negligible (USEPA, 1978c), the proposed wet scrubber system design is optimized for collection of gaseous constitutents and is expected to remove some of any gaseous fluoride that may be generated in the dryers (a maximum of approximately 0.04 lb/hr; 0.18 TPY). By scaling this value in proportion to predicted maximum $SO_2$ emissions, the expected maximum annual and 24-hour concentrations of gaseous fluorides would be approximately 0.0008 $\mu g/m^3$ and 0.005 $\mu g/m^3$, respectively, from the proposed operation.

Estimates of particulate fluoride deposition were made using the ISC model (Environmental Science and Engineering, Inc., 1981b). These calculations were based on PM emissions from the rock dryer and scrubbers and information on particle size distribution for phosphate rock dryers. The maximum calculated 24-hour particulate deposition was $3.9 \times 10^{-4} g/m^2$. Conservatively assuming a 3-percent fluoride content by weight, the maximum 24-hour fluoride deposition would only be $1.2 \times 10^{-5} g/m^2$. The maximum annual average deposition of fluoride was calculated to be less than $1.5 \times 10^{-3}$ $g/m^2$. Fluoride deposition of this magnitude is not expected to result in adverse effects.

Fugitive dust control systems as proposed would prevent fugitive dust emissions from the point of dry product discharge at the dryers and recovery cyclones to and including the point where product enters railroad hopper cars. The belts conveying dry rock between transfer points would be enclosed to prevent wind erosion during handling; all transfer points would be enclosed and the storage silos and loadout bins would be exhausted during loading operations to prevent the escape of fugitive dust by air displacement. Also, specially designed loading spouts would be used at rail car loading hatches to collect displaced air to prevent the escape of fugitive dust from the hatch openings, and all inflow air would be exhausted through dust collection system ducts and routed to air pollution control systems. These fugitive dust collection and control systems would limit the emissions to fine phosphate rock and clay particulate matter.

Fugitive particulate matter (dust) generated by incoming rock would be controlled by wet scrubbers located on top of the silos, and fugitive emissions generated by transferring stored rock on conveyors belts for transport to loadout stations would be controlled by a venturi scrubber located at ground level. Fugitive emissions generated by the dry rock loadout and transfer operations would be controlled by two wet scrubbers (one at each station) and completely enclosed conveyors which are expected to prevent the escape of emissions to the atmosphere. Because these fugitive emissions are controlled and released from specific control points (scrubbers 1-4 in Table III-1), they are listed as PM sources rather than fugitive dust sources in Table III-1. Other minor fugitive emissions associated with the MCC complex would be those generated during construction and the increased vehicular activity during normal operations. Additional minor fugitive emissions would be generated from the dry rock at the loadout point to the Tampa Bay area and during the loading into the barges at Tampa Bay.

### 3.1.4 Effects on Prevention of Significant Deterioration (PSD) Increments

In assessing the air quality effects of the emissions from the proposed MCC phosphate mine, attention must also be given to the consumption of PSD increments.

The USEPA has defined ambient concentrations that separate "significant" from "insignificant" impacts (43FR26388,44FR3274). From the point at which calculated concentrations attributable to the emissions of a proposed new source become less than the significant impact levels, these emissions can be considered negligible with respect to effects on PSD Class II areas and nonattainment areas. Table III-4 contains the PSD Class I and Class II increment limits. Also listed are the significant impact levels for Class II areas, model-calculated pollutant concentrations below these levels are considered to have no significant impact on air quality.

The estimated maximum increment consumption of the proposed phosphate rock processing complex is based upon maximum annual and highest, second-highest short-term calculated concentrations. Since there are no PSD increment limits for $NO_2$ or CO, only $SO_2$ and PM concentrations must be demonstrated to fall within the PSD increment limits. Table III-5 sets forth these increment limits together with maximum calculated concentrations resulting from the proposed action and interacting sources for comparison.

Based upon the modeling results, the FPL Manatee, IMC, and AGRICO sources interact with MCC to produce relatively small maximum concentrations in the affected area as presented in Table III-6. The combined concentrations produced by the other sources interacting with MCC is less than the projected maximum increment consumption by the MCC complex alone. Due to the distances to these interacting sources, the maximum concentration due to MCC alone occurs at a different place and under different meteorological conditions than do the maxima for the interactive cases.

Because the Chassahowitzka Class I area is located more than 100 km from the MCC complex (approximately 140 km), the presumption exists that no significant effect would occur upon this area due to MCC's proposed phosphate rock processing facility. Steady-state Gaussian modeling results confirm this presumption (Environmental Science and Engineering, 1981).

Also, there should not be a significant impact on the Pinellas $SO_2$ and Tampa TSP nonattainment areas. These areas are approximately 100 and 60 km away, respectively. The maximum calculated $SO_2$ and PM concentrations are well below the applicable significant levels at these locations.

### 3.1.5 Additional Impacts

Impacts on soils and vegetation from air pollutants associated with the proposed phosphate rock processing operations are expected to be of minor significance. As was presented in Table III-3, the projected highest, second-highest 3-hour $SO_2$ concentration of 315 $\mu g/m^3$ and the annual mean concentration of 10 $\mu g/m^3$ are well below levels generally reported for damage to sensitive plant species. Particulate matter is generally considered to have relatively unimportant effects on vegetation. However, particulates from the MCC complex may contain about 1 1/2 to 3 percent fluorides. Since background levels of PM are low in the vicinity of MCC's proposed operations and the projected impact levels due to operations are less than the background, it is expected that no significant fluoride impact on vegetation will occur as a result of the predicted increase in emissions.

No effect on plants or soils is expected from the low annual concentrations (1 $\mu g/m^3$) of $NO_2$ predicted to occur due to the proposed complex.

The proposed MCC source is not expected to significantly impair the visibility in the immediate area of the action, in the nearest PSD Class I area or in the nearest nonattainment areas. During the construction phase there would be a small transient impact on the local visibility due to fugitive dust raised by construction activity.

### 3.1.6 Summary

The proposed mining operation would result in a minor degradation of air quality in the vicinity of the mine site as a result of:

1. Combustion emissions associated with the operation of the phosphate rock dryer and the boilers at the site; and
2. Fugitive dust (particulate matter) associated with the rock dryer, boilers, scrubbers, transfer and handling of the phosphate rock and vehicular movement.

Based upon the atmospheric dispersion modeling results using worst-case meteorological conditions, 100-percent load conditions, and maximum allowable emissions from all MCC's operations including interacting sources, it is predicted that the allowable Class II PSD increments would not be exceeded as a result of the proposed MCC phosphate rock mining/processing operation. Also, no existing ambient air quality standard is expected to be exceeded, and no existing designated nonattainment areas would be significantly affected by this action. No significant impacts are expected upon soils, vegetation, and visibility in the area of the MCC plant.

The proposed MCC phosphate rock processing complex is expected to comply with all state and Federal PSD and air quality regulations. No NSPS would apply, but appropriate control techniques (generally BACT) would be used to control emissions.

## 3.2 DRY ROCK AT PASCAGOULA (ALTERNATIVE 1)

Two basic methods of handling phosphate rock from MCC's proposed Florida mining and beneficiation facilities were evaluated. The proposed action is the use of an on-site rock dryer at the Ona mine site. The second method eliminates rock drying at the mine. Two alternatives were considered for the case of no rock dryer at Ona: Alternative 1: to dry the phosphate rock at MCC's chemical processing facilities in Pascagoula, Mississippi (Figure III-2), and Alternative 2: to process wet rock at Pascagoula. The projected emissions associated with the proposed action and each alternative are presented in Tables III-7 and III-8 for comparison. The air quality effects of each alternative are compared in Table III-9. (As discussed in Section 3.1, emissions from temporary activities and mining were not included in the dispersion modeling.) A discussion of Alternative 1 effects is contained in this section.

The same options are available to other customers purchasing wet rock from MCC; however, no air quality impact analysis can be performed without knowledge of the customer facilities.

This alternative eliminates rock drying at the Florida mine site. Wet rock loading facilities would be provided at the mine site and wet rock would be shipped by railroad cars to port facilities in the Tampa Bay area. From the port, approximately 1.0 million TPY of wet rock would be barge-shipped to MCC's Pascagoula facility where it would be dried and processed. The primary differences from Alternative 2 (Section 3.3) would be (1) the addition of a rock dryer, together with a small boiler, to handle 1 million tons/year of rock; (2) retention of the present dry rock handling facilities; and (3) elimination of the new steam generator, all at Pascagoula. Projected emissions are listed in Tables III-7 and III-8.

### 3.2.1 Ona Mine Site

There are no emissions from rock drying at Ona for this alternative. Also, there are no emissions from boiler 2 or for dry rock storage and transport (Table III-7). Total operating emissions are substantially reduced at the mine site from those with the proposed action. Predicted concentrations are presented in Table III-9. The results at Ona for both alternatives were determined by scaling the values calculated for the proposed action.

#### 3.2.1.1 Sulfur Dioxide

As shown in Table III-9, the calculated maximum annual average $SO_2$ concentration at Ona is 4 $\mu g/m^3$, determined by summing the maximum predicted and ambient background concentrations. The highest, second-highest 24-hour and 3-hour ambient concentrations are 71 and 166 $\mu g/m^3$, respectively, including the background concentrations.

#### 3.2.1.2 Particulate Matter

The predicted PM impacts at Ona for the alternative actions are well below applicable AAQS. The maximum annual average concentration is 28 $\mu g/m^3$ (calculated plus background), which is 47 percent of the Florida AAQS. The highest, second-highest 24-hour concentration is 91 $\mu g/m^3$; this is 61 percent of the Florida AAQS.

#### 3.2.1.3 Other Pollutants

Nitrogen oxide ($NO_x$), carbon monoxide (CO), and hydrocarbon (HC) emissions are reduced significantly at the mine site for the alternative actions. As shown in Table III-9 for the mine site, no significant impact is expected. Gaseous fluoride emissions and fluoride deposition, as earlier described for the proposed action, were relatively insignificant. Since the rock drying operation would be eliminated under this alternative, gaseous fluorides should not be generated and any particulate fluoride deposition should be very minor.

### 3.2.1.4 PSD Increments

As defined for the proposed action (Section 3.1.2), the predicted maximum increment consumption was based upon maximum annual and highest, second highest short-term calculated concentrations. These values have been proportionally scaled down based on the reduced source emissions for this alternative; the results are presented in Table III-9. Since consideration of MCC emissions alone produced the highest increment consumption based upon dispersion modeling of the combined increment consumption by FPL Manatee and MCC in the interacting direction, no combined consumption values are considered now for this alternative. This comparison shows that the 3-hour $SO_2$ increment consumption is reduced from 158 to 9 $\mu g/m^3$. The 24-hour PM increment consumption is reduced from 16 to 1 $\mu g/m^3$. Also, there is no predicted consumption in the Pinellas $SO_2$ and Tampa PM nonattainment areas.

### 3.2.1.5 Additional Impacts

Other impacts would be greatly reduced by eliminating the rock drying and therefore would be even less significant than for the proposed action.

### 3.2.2 Pascagoula Site

There would be no increase in emissions at Pascagoula for the proposed action. For Alternative 1, approximate emission increases are shown in Table III-8; these would be produced at Pascagoula as a result of adding a rock dryer. The small boiler which would be required at the Ona mine site to heat fuel oil used in a dryer might or might not be required at Pascagoula depending on the availability of excess steam from chemical processing facilities. Since emissions from this boiler are minor, they have not been included in the evaluation of Alternative 1 (and therefore have not been included in Table III-8).

The amount of rock which would be dried at Pascagoula would be roughly a third of that proposed for the Ona mine site dryer. Pascagoula dryer emissions have been derived from Ona dryer emissions based on this difference in rock drying rates. It is not certain that the same type of fuel oil would be used in the Pascagoula dryer as in the Ona dryer, or that a dryer with a smaller drying capacity would produce the same emissions per pound of rock dried even if the same fuel were used. Therefore, emissions rates for the Pascagoula dryer should be considered as only approximate.

Estimates of ambient effects resulting from operation of a rock dryer at MCC's Pascagoula chemical complex were obtained by reference to a PSD permit application prepared for a project adjacent to MCC's property (Dames & Moore, 1980). One of the emission sources involved in this project is somewhat similar to the MCC rock dryer in terms of characteristics affecting atmospheric dispersion (stack height and plume rise). Ambient concentrations have been predicted for this similar source through the use of USEPA-approved dispersion models and meteorological data representative of the Pascagoula area. These concentrations can be considered as an approximation of ambient effects attributable to rock dryer operation after an appropriate scaling to take into account differences in emission rates. A detailed source-specific modeling analysis would of course eventually be needed if a permit were actually sought for a rock dryer at Pascagoula, but the scaled concentrations derived from predictions for a somewhat similar nearby source can be used to approximate rock dryer effects in comparison with applicable ambient air quality limits.

### 3.2.2.1 Compliance with Ambient Air Quality Standards

Compliance of Alternative 1 with National Ambient Air Quality Standards (NAAQS) was evaluated by adding maximum concentrations estimated to result from dryer emissions to representative concentrations which have been measured in the area of MCC's Pascagoula chemical complex (as reported in Dames & Moore, 1980). Results are presented in Table III-9 and summarized below. It should be noted that this procedure does not take into account the effect of new emission sources not yet in operation, but which are likely to begin operation before a dryer could be developed at MCC if needed. This fact further adds to the approximate nature of the results.

1. Sulfur Dioxide - Maximum predicted 3-hour, 24-hour, and annual average concentrations with a dryer in operation are on the order of 450, 150, and 25 $\mu g/m^3$, compared with NAAQS of 1,300, 365, and 80 $\mu g/m^3$ for the same averaging periods.
2. Particulate Matter - Predicted concentrations atrributable to an MCC rock dryer are less than concentrations which the USEPA has defined as significant (5 $\mu g/m^3$ for a 24-hour average and 1 $\mu g/m^3$ for an annual average).
3. Nitrogen Dioxide - A maximum annual average concentration of approximately 25 $\mu g/m^3$ is predicted with a dryer in operation compared with the NAAQS of 100 $\mu g/m^3$.

Emissions of pollutants other than $SO_2$, PM, and $NO_2$ from a Pascagoula rock dryer are expected to be insignificant (using the USEPA definition of significant emissions), and therefore do not require an ambient impact analysis.

The tentative conclusion reached based on these approximate results is that a rock dryer could be operated in Pascagoula without causing a violation of ambient air quality standards. This conclusion would hold even if the concentrations presented above were increased substantially to allow for other new sources beginning operation prior to development of an MCC rock dryer.

### 3.2.2.2 Compliance with PSD Increments

MCC's Pascagoula chemical complex is located in a designated PSD Class II Area. The nearest PSD Class I area is the Breton National Wilderness Area, lying within an island chain in the Gulf of Mexico. At its closest point this Class I area is approximately 50 km from the MCC chemical complex.

#### Sulfur Dioxide

Maximum 3-hour, 24-hour, and annual average $SO_2$ concentration attributable to dryer emissions are on the order of 150, 40, and 5 $\mu g/m^3$. These values are less than 50 percent of applicable PSD Class II increments. Considering MCC emissions alone, therefore, it would appear that Class II increments could be met. There is at least one other large PSD increment-consuming source in the immediate vicinity of the MCC chemical complex, however. Interactions between MCC and this other source (an oil refinery) would have to be evaluated in detail before reaching a definite conclusion on Class II $SO_2$ increment compliance. Without having the detailed emissions data needed to perform this analysis, the tentative conclusion reached at this time is that an interaction analysis would still show compliance with Class II increments, but a large percentage of 3-hour and 24-hour increments would be consumed.

In the Breton PSD Class I area, maximum predicted 3-hour, 24-hour, and annual average $SO_2$ concentrations attributable to dryer emissions are on the order of 6, 1, and less than 1 $\mu g/m^3$, all of which are less than Class I increments. Again, however, MCC effects must be considered in combination with effects of other nearby increment-consuming sources. An approximate preliminary evaluation of interaction effects suggests that Class I increments could possibly be met, but only by a very narrow margin.

### Particulate Matter

Ambient PM concentrations attributable to dryer emissions are less than the USEPA significance levels and therefore do not require further analysis for comparison with PSD increments.

### Conclusion

The tentative results obtained through evaluation of dryer emissions indicate that PSD increments could possibly be met, but that a more detailed analysis would be needed to verify compliance with short-term (3-hour and 24-hour) Class I and Class II $SO_2$ increments when interactions with other emission sources are taken into account. Part of this more detailed analysis would be a review of regulatory requirements to determine the sulfur content of fuel oil which would be considered Best Available Control Technology in the Pascagoula area.

### 3.2.2.3 Effect on Nearest Nonattainment Areas

There are no nonattainment areas (areas where ambient concentrations exceed NAAQS) close enough to be affected by those pollutants emitted in significant quantities from a rock dryer of the size required at Pascagoula.

### 3.3 PROCESS WET ROCK AT PASCAGOULA (ALTERNATIVE 2)

This alternative also eliminates rock drying at the mine site; total mine output would be produced as wet rock (13 percent by weight water). Wet rock loading facilities would be provided at the mine site and wet rock would be shipped by railroad cars to port facilities in the Tampa Bay area. From the port, approximately 1.0 million TPY of wet rock would be barge-shipped to MCC's Pascagoula facility where it would be processed as wet rock (see Figure III-2). In addition, approximately 51,000 TPY of dry rock would be barge-shipped from other sources to the Pascagoula facility in order to satisfy triple superphosphate (TSP) production requirements.

#### 3.3.1 Ona Mine Site

All activities at the Ona mine site would be the same as for Alternative 1 described previously in Section 3.2.1.

#### 3.3.2 Pascagoula

Alternative 2 would require a new boiler at MCC's Pascagoula chemical complex for the purpose of producing steam for evaporation of excess water resulting from the wet rock process. This new boiler would be by far the major source of increased emissions associated with Alternative 2.

A key item related to boiler emissions is the percentage of sulfur which would be allowed in the oil used for boiler fuel. Current New Source Performance Standards (NSPS) for fossil-fuel steam generators restrict sulfur content in No. 6 fuel oil to about one percent by weight (assuming emission control is achieved solely through regulation of fuel sulfur content). However, the NSPS limit does not apply to a boiler of the size required at Pascagoula (approximately 130 million Btu heat input per hour). To insure that ambient effects were not substantially underestimated, a sulfur content of two percent was assumed, although it is quite possible that Best Available Control

Technology in this case might have to approximate the NSPS limit. Estimated boiler emissions based on two-percent sulfur fuel oil are shown in Table III-8.

The methodology used to evaluate ambient effects of boiler emissions is identical to that described for Pascagoula rock dryer emissions. That is, ambient concentrations attributable to boiler emissions were roughly estimated based on a recent modeling study performed for a similar emission source proposed for development near the MCC site (Dames & Moore, 1980).

### 3.3.2.1 Compliance with Ambient Air Quality Standards

Compliance of Alternative 2 with NAAQS was evaluated by adding maximum concentrations estimated to result from boiler emissions to representative concentrations which have been measured in the area of MCC's Pascagoula chemical complex (as reported in Dames & Moore, 1980). Results are presented in Table III-9. These results can be summarized as follows:

1. Sulfur Dioxide - Maximum predicted 3-hour, 24-hour, and annual average concentrations with a boiler in operation using 2 percent sulfur fuel oil are on the order of 550, 200, and 30 $\mu g/m^3$ for the same averaging periods.
2. Particulate Matter - Predicted annual average concentrations attributable to an MCC boiler are less than the USEPA significance levels. The maximum predicted 24-hour concentration is approximately the same as the USEPA significance level; but, allowing for the decrease in dry rock handling emissions which would accompany a switch to wet rock processing, the net increase in PM concentrations would probably be insignificant.

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3. Nitrogen Dioxide - A maximum annual average of approximately 30 $\mu g/m^3$ is predicted with a boiler in operation, compared with the NAAQS of 100 $\mu g/m^3$.

Emissions of pollutants other than $SO_2$, PM, and $NO_2$ from a new Pascagoula boiler using No. 6 fuel oil are expected to be insignificant (again using the USEPA's significant emissions definition), and therefore do not require an ambient impact analysis.

The tentative conclusion reached, based on these estimates, is that a boiler could be operated in Pascagoula without causing a violation of ambient air quality standards. This conclusion would hold even if measured baseline concentration were increased substantially to allow for other new sources beginning operation prior to development of a new MCC boiler.

### 3.3.2.2 Compliance with PSD Increments

#### Sulfur Dioxide

Maximum 3-hour, 24-hour, and annual average $SO_2$ concentrations attributable to boiler emissions with two percent sulfur oil are on the order of 260, 85, and 10 $\mu g/m^3$. These values are less than applicable PSD Class II increments, although the maximum 24-hour value is close to the increment limit of 91 $\mu g/m^3$. When interactions with other increment-consuming sources in the area are considered, a possible problem in meeting short-term Class II $SO_2$ increments is indicated. This does not mean that a new boiler would not be permitted, it simply means that (1) a detailed interactions analysis would be necessary, and (2) a lower sulfur content fuel oil (and the corresponding cost penalty) might be needed to insure increment compliance.

In the Breton PSD Class I Area, maximum predicted 3-hour, 24-hour, and annual average $SO_2$ concentrations attributable to boiler emissions are on the order of 9, 2, and less than 1 $\mu g/m^3$. Although these levels are individually less than Class I increments, the

3-hour and 24-hour concentrations are great enough to pose a potential increment consumption problem when coupled with effects attributable to other emission sources in the same area. This again points to the need for more detailed analysis and to the possible need for greater restriction on fuel oil sulfur content.

Particulate Matter

Ambient PM concentrations attributable to boiler emissions within the surrounding PSD Class II area are less than the USEPA significance levels when a slight allowance is made for reduced emissions from dry rock handling facilities. (No allowance is needed to show the insignificance of PM concentrations within the Breton PSD Class I Area.)

Conclusion

The tentative results obtained through evaluation of boiler emissions is that there might be a problem in showing compliance with short-term PSD increments for $SO_2$ when a fuel oil sulfur content of two percent is assumed and when interactions with other increment-consuming sources are considered. This conclusion means that before a new boiler at the MCC Pascagoula chemical complex could be permitted, a detailed source interaction analysis would be needed and a decision on fuel oil sulfur content would have to be reached in discussion with regulatory agencies.

### 3.2.2.3 Effect on Nearest Nonattainment Areas

There are no nonattainment areas close enough to be affected by those pollutants emitted in significant quantities from a boiler of the size required at Pascagoula.

## 3.4 SUMMARY OF ALTERNATIVE EFFECTS

Both alternatives to the proposed action involve reductions in air quality effects in the area of the Ona mine site, but they each involve significant increases in the air quality effects in the area of MCC's Pascagoula, Mississippi, phosphate chemical processing facility. The Pascagoula area air quality analyses took advantage of readily available previous modeling results done for a PSD permit application for a nearby project. The level of analysis reported here was deemed appropriate to the decision-making function of the EIS process.

The results of the Pascagoula area air quality evaluations for both alternatives raise questions about possible permitting problems related to the levels of increased sulfur dioxide emissions assumed for each alternative. Although these alternatives would not necessarily in themselves threaten PSD Class I and II increment limits, they would require careful analysis because of potential interaction with other increment-consuming sources.

If either of the alternatives is selected over the proposed action, then the air quality permitting issues raised here would have to be addressed in a careful and extensive dispersion modeling effort as part of a PSD permit application for the Pascagoula site modification. This extensive modeling effort would be based on more refined engineering and design information than is currently available.

# 4.0 MITIGATIVE MEASURES

The unavoidable impacts described in Section 3.0 would be limited, and other avoidable impacts would be mitigated, by the actions summarized below for the proposed action and each of the alternative actions.

## 4.1 DRY ROCK AT MINE SITE (PROPOSED BY MCC)

The proposed action (and the analysis of impacts presented in Section 3.1) includes the following mitigative measures:

1. Construction equipment and personnel would be limited to established access roads to and from the mine complex. No cross-country vehicular activity would be permitted. At termination of the mining operation, vehicular access to the mine site would be eliminated, except along established roadways as part of planned land uses.
2. Dust would be suppressed during the time construction activity is taking place by periodically traversing all roads and construction areas with a water spray truck as needed.
3. The beneficiation plant operation would be a totally wet process. Emissions from the fluid bed dryer would be controlled by a wet scrubber. Dry rock emissions from the bank of dry rock storage silos would be controlled by a wet scrubber process, and the emissions (fugitive particulates) generated by transferring stored rock onto conveyor belts for transport to the loadout stations would be controlled by a venturi scrubber. Also, the dry rock loadout operation would have its particulate matter emissions controlled by two wet scrubbers. The dry rock conveyors and transfer point would be completely enclosed. Best available control technology for all affected pollutants would be met by the use of appropriate control techniques and established quality control procedures

for the operation of the dryer, associated storage, and transfer operations. The loadout bins would discharge to railroad hopper cars through specially designed fugitive dust control spouts. The spouts seal the railroad car hatches and exhaust air into a collection system which is controlled by the wet scrubbing process described above for dry and/or wet phosphate rock operations.

4. Following completion of various phases of the project, soil surfaces would be inspected periodically to be certain that soil stabilization is occurring and that erosion is minimized. In the event of severe wind or water erosion, appropriate soil stabilization measures would be taken.
5. The effectiveness of the environmental protection actions described above would be under surveillance throughout the project to be sure that environmental protection is proceeding as planned. Follow-up actions to determine the effectiveness of the measures adopted to protect the environment would be accomplished.

Other mitigating actions such as fuel switching (low-sulfur fuel vs. high sulfur fuel utilization) are available for consideration as mitigating techniques should they be necessary.

## 4.2 DRY ROCK AT PASCAGOULA SITE (ALTERNATIVE 1)

If selected, this alternative would be mitigated by the following measures:

1. Mitigative measures 1., 2., 4., and 5. under Section 4.1 above would still apply to the MCC mine complex at Ona.
2. Emissions from the fluid bed dryer and all dry rock operations transferred to Pascagoula under this alternative action would

be controlled as defined for the proposed action at Ona. Also, the need to switch to a low-sulfur fuel oil for the dryer would be evaluated.

## 4.3 WET ROCK PROCESSING (ALTERNATIVE 2)

1. Mitigative measures 1., 2., 4., and 5. under Section 4.1 above would still apply to the MCC mine complex at Ona.
2. Consideration would be given to the use of low-sulfur fuel oil to reduce sulfur dioxide emissions from the new boiler at Pascagoula.

## TABLE III-1

## ESTIMATED ATMOSPHERIC EMISSIONS, MCC COMPLEX, WITH CONTROLS

| PHASE/FACILITY | POLLUTANT (ACTUAL)[a] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $SO_2$ | | $NO_x$ | | CO | | HC | | PM | | Fugitive Dust[b] | | Gaseous Fluorides | |
| | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY |
| Temporary | | | | | | | | | | | | | | |
| Site Preparation | -- | -- | 0.71 | 3.14 | 23.62 | 103.44 | 3.93 | 17.24 | 2.86 | 12.54 | -- | -- | -- | -- |
| Construction | 2.15 | 9.40 | 35.78 | 156.73 | 16.46 | 72.09 | 3.22 | 14.11 | 2.15 | 9.40 | 19.68 | 86.20 | -- | -- |
| Sub Total | 2.15 | 9.40 | 36.49 | 159.87 | 40.08 | 175.43 | 7.15 | 31.35 | 4.96 | 21.94 | 19.68 | 86.20 | -- | -- |
| Mining/Operation and Processing | | | | | | | | | | | | | | |
| Mining | 2.76 | 12.07 | 5.58 | 24.45 | 1.79 | 7.84 | 0.40 | 1.73 | 0.42 | 1.83 | 20.00 | 87.60 | -- | -- |
| Wet Rock Storage | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 48.31 | 211.29[c] | -- | -- |
| Boiler #1 | 18.36 | 80.42 | 3.02 | 13.23 | 0.26 | 1.14 | 0.05 | 0.22 | 1.33 | 5.82 | -- | -- | -- | -- |
| Boiler #2 | 10.94 | 47.92 | 1.80 | 7.88 | 0.16 | 0.70 | 0.03 | 0.13 | 0.79 | 3.46 | -- | -- | -- | -- |
| Phosphate Rock Dryer | 286.13 | 1,253.25 | 78.30 | 342.95[e] | 6.75 | 29.57[d] | 1.35 | 5.91[d] | 20.28 | 88.83 | -- | -- | 0.04 | 0.18 |
| Sub Total | 318.19 | 1,393.66 | 88.70 | 388.51 | 8.96 | 39.25 | 1.83 | 7.99 | 22.82 | 99.94 | 68.31 | 298.89 | 0.04 | 0.18 |
| Dry Rock Storage and Transport | | | | | | | | | | | | | | |
| Scrubber #1 | -- | -- | -- | -- | -- | -- | -- | -- | 2.22 | 9.72 | -- | -- | -- | -- |
| Scrubber #2 | -- | -- | -- | -- | -- | -- | -- | -- | 5.70 | 25.00 | -- | -- | -- | -- |
| Scrubber #3 | -- | -- | -- | -- | -- | -- | -- | -- | 3.16 | 13.80 | -- | -- | -- | -- |
| Scrubber #4 | -- | -- | -- | -- | -- | -- | -- | -- | 3.16 | 13.80 | -- | -- | -- | -- |
| Sub Total | -- | -- | -- | -- | -- | -- | -- | -- | 14.24 | 62.32 | -- | -- | -- | -- |
| Facility Total | 320.34 | 1,403.06 | 125.19 | 548.38 | 49.04 | 214.68 | 8.98 | 39.34 | 42.02 | 184.20 | 87.99 | 385.39 | 0.04 | 0.18 |
| Transportation | | | | | | | | | | | | | | |
| Railroad/Barge | 0.02 | 0.09 | 1.65 | 7.21 | 3.86 | 16.93 | 0.71 | 3.13 | 0.01 | 0.55 | -- | -- | -- | -- |
| Project Total | 320.36 | 1,403.96 | 126.84 | 555.59 | 52.90 | 231.61[d] | 9.69 | 42.47[d] | 42.03 | 184.75 | 87.99 | 385.39[c] | 0.04 | 0.18 |

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[a] Includes reduction due to proposed controls.

[b] Fugitive dust emissions include a substantial weight percent of coarse particulate matter (unlike dryer emissions) that will redeposit relatively close to the point of emission.

[c] Analysis of product particle size suggests methodology produces substantial overestimation (99.98% > 40 μ m).

[d] Pollutant loadings generated by fuel combustion process for equivalent industrial boiler capacity. Reduced generation and/or removal may be expected in fluidized bed dryers and wet scrubbing devices.

[e] Based on field measurements conducted on a similar fluosolids dryer.

## TABLE III-2

## ESTIMATED ATMOSPHERIC EMISSIONS, MCC COMPLEX, WITHOUT CONTROLS

| | POLLUTANT (POTENTIAL)[a] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $SO_2$ | | $NO_x$ | | CO | | HC | | PM | | Fugitive Dust[b] | | Gaseous Fluorides | |
| PHASE/FACILITY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY | LBS/HR | TPY |
| Temporary | | | | | | | | | | | | | | |
| Site Preparation | -- | -- | 0.71 | 3.14 | 23.62 | 103.44 | 3.93 | 17.24 | 2.86 | 12.54 | -- | -- | -- | -- |
| Construction | 2.15 | 9.40 | 35.78 | 156.73 | 16.46 | 72.09 | 3.22 | 14.11 | 2.15 | 9.40 | 19.68 | 86.20 | -- | -- |
| Sub Total | 2.15 | 9.40 | 36.49 | 159.87 | 40.08 | 175.43 | 7.15 | 31.35 | 4.96 | 21.94 | 19.68 | 86.20 | -- | -- |
| Mining/Operation and Processing | | | | | | | | | | | | | | |
| Mining | 2.76 | 12.07 | 5.58 | 24.45 | 1.79 | 7.84 | 0.40 | 1.73 | 0.42 | 1.83 | 20.00 | 87.60 | -- | -- |
| Wet Rock Storage | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 48.31 | 211.29[c] | -- | -- |
| Boiler #1 | 18.36 | 80.42 | 3.02 | 13.23 | 0.26 | 1.14 | 0.05 | 0.22 | 1.33 | 5.82 | -- | -- | -- | -- |
| Boiler #2 | 10.94 | 47.92 | 1.80 | 7.88 | 0.16 | 0.70 | 0.03 | 0.13 | 0.79 | 3.46 | -- | -- | -- | -- |
| Phosphate Rock Dryer | 476.89 | 2,088.78 | 78.30 | 342.95[e] | 6.75 | 29.57[d] | 1.35 | 5.91[d] | 21,600 | 94,608 | -- | -- | 0.04 | 0.18 |
| Sub Total | 508.95 | 2,229.19 | 88.70 | 388.51 | 8.96 | 39.25 | 1.83 | 7.99 | 21,603 | 94,619 | 68.31 | 298.89 | 0.04 | 0.18 |
| Dry Rock Storage and Transport | | | | | | | | | | | | | | |
| Scrubber #1 | -- | -- | -- | -- | -- | -- | -- | -- | 792 | 3,469 | -- | -- | -- | -- |
| Scrubber #2 | -- | -- | -- | -- | -- | -- | -- | -- | 2,037 | 8,922 | -- | -- | -- | -- |
| Scrubber #3 | -- | -- | -- | -- | -- | -- | -- | -- | 1,131 | 4,956 | -- | -- | -- | -- |
| Scrubber #4 | -- | -- | -- | -- | -- | -- | -- | -- | 1,131 | 4,956 | -- | -- | -- | -- |
| Sub Total | -- | -- | -- | -- | -- | -- | -- | -- | 5,091 | 22,303 | -- | -- | -- | -- |
| Facility Total | 511.10 | 2,238.59 | 125.19 | 548.38 | 49.04 | 214.68 | 8.98 | 39.34 | 26,699 | 116,944 | 87.99 | 385.39 | 0.04 | 0.18 |
| Transportation | | | | | | | | | | | | | | |
| Railroad/Barge | 0.02 | 0.09 | 1.65 | 7.21 | 3.86 | 16.93 | 0.71 | 3.13 | 0.01 | 0.55 | -- | -- | -- | -- |
| Project Total | 511.12 | 2,238.68 | 126.84 | 555.59 | 52.90 | 231.61[d] | 9.69 | 42.47[d] | 26,699 | 116,945 | 87.99 | 385.39[c] | 0.04 | 0.18 |

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[a] Excludes reduction due to proposed controls.

[b] Fugitive dust emissions include a substantial weight percent of coarse particulate matter (unlike dryer emissions) that will redeposit relatively close to the point of emission.

[c] Analysis of product particle size suggests methodology produces substantial overestimation (99.98% > 40 $\mu$m).

[d] Pollutant loadings generated by fuel combustion process for equivalent industrial boiler capacity. Reduced generation and/or removal may be expected in fluidized bed dryers and wet scrubbing devices.

[e] Based on field measurements conducted on a similar fluosolids dryer.

## TABLE III-3

## MAXIMUM CALCULATED GROUND-LEVEL CONCENTRATIONS FOR CRITERIA POLLUTANTS EMITTED BY THE PROPOSED MCC COMPLEX[a]

| Pollutant | Averaging Time | Concentration ($\mu g/m^3$) | | | |
|---|---|---|---|---|---|
| | | Calculated Impact | Ambient Background[b] | Calculated Plus Background | State of Florida Standard |
| Sulfur Dioxide | 3-Hour | 158 | 157 | 315 | 1,300[d] |
| | 24-Hour | 41 | 69 | 110 | 260[d] |
| | Annual Arithmetic Mean | 6 | 4 | 10 | 60 |
| Particulate Matter | 24-Hour | 16 | 90 | 106 | 150[d] |
| | Annual Geometric[c] Mean | 2 | 28 | 30 | 60 |
| Carbon Monoxide | 1-Hour | 3 | -- | -- | 40,000[d] |
| | 8-Hour | 2 | -- | -- | 10,000[d] |
| Nitrogen Dioxide | Annual Arithmetic Mean | 1 | -- | -- | 100 |

---

[a] Short-term impacts represent highest, second-highest concentrations.
[b] Based upon highest recorded concentrations from ambient monitoring.
[c] Calculated from the annual arithmetic mean and geometric standard deviation obtained from ambient monitoring.
[d] Not to be exceeded more than once per year at any specified location.

Source: Environmental Science and Engineering, Inc., 1981a.

## TABLE III-4

## APPLICABLE AMBIENT AIR QUALITY LIMITS
(in μg/$m^3$ unless otherwise indicated)

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| Pollutant and Averaging Period | NAAQS |  | AAQS | PSD Class II Increments | PSD Class I Increments | PSD Class II Significant Impact Levels |
|---|---|---|---|---|---|---|
|  | Primary | Secondary | State of FLorida |  |  |  |
| Sulfur Dioxide |  |  |  |  |  |  |
| 3-Hour[a] | -- | 1300 | 1300 | 512 | 25 | 25 |
| 24-Hour[a] | 365 | -- | 260 | 91 | 5 | 5 |
| Annual[b] | 80 | -- | 60 | 20 | 2 | 1 |
| Total Suspended Particulates |  |  |  |  |  |  |
| 24-Hour[a] | 260 | 150 | 150 | 37 | 10 | 5 |
| Annual[c] | 75 | 60[d] | 60 | 19 | 5 | 1 |
| Nitrogen Dioxide |  |  |  |  |  |  |
| Annual[b] | 100 | 100 | 100 | -- | -- | 1 |
| Ozone |  |  |  |  |  |  |
| 1-Hour[e] | 0.12[f] | 0.12[f] | 0.12[f] | -- | -- | -- |
| Carbon Monoxide |  |  |  |  |  |  |
| 1-Hour[a] | 40000 | 40000 | 40000 | -- | -- | 2000 |
| 8-Hour[a] | 10000 | 10000 | 10000 | -- | -- | 500 |

---

[a] Not to be exceeded more than once a year. (This provision does not apply to significant impact levels.)

[b] Arithmetic mean.

[c] Geometric mean.

TABLE III-4 (Continued)

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[d] To be used as a guide in assessing implementation plans to achieve the 24-hour standard.

[e] The expected number of days per year with maximum hourly concentrations above 0.12 pm must be less than or equal to one.

[f] Concentration in ppm.

## TABLE III-5

## HIGHEST, SECOND-HIGHEST CALCULATED SHORT-TERM $SO_2$ AND PM CONCENTRATION ($\mu g/m^3$) FOR PROPOSED MCC COMPLEX, INTERACTION SOURCES AND ALLOWABLE PSD CLASS II INCREMENTS

| Pollutant | PSD Increments | MCC Only | MCC/Wauchula Power and American Orange | MCC/Mancini Packing | MCC/ FPL Manatee | MCC/ IMC | MCC/ AGRICO |
|---|---|---|---|---|---|---|---|
| 3-Hour $SO_2$ | 512 | 158 | 110 | 100 | 98 | 87 | 53 |
| 24-Hour $SO_2$ | 91 | 41 | 29 | 30 | 26 | 20 | 20 |
| 24-Hour PM | 37 | 16 | 8 | 7 | 9 | -- | 7 |

Source: Environmental Science and Engineering, Inc., 1981a.

TABLE III-6

SUMMARY OF PSD INCREMENT CONSUMPTION RESULTS FOR PROPOSED MCC COMPLEX

| Pollutant | Maximum[a] Increment Consumption ($\mu g/m^3$) Averaging Time 3-Hour | 24-Hour | Annual |
|---|---|---|---|
| Sulfur Dioxide | | | |
| MCC Point of Maximum Impact | 158 | 41 | 6 |
| MCC and FPL Manatee Interaction | 98 | 26 | -- |
| MCC and IMC Interaction | 87 | 20 | -- |
| MCC and AGRICO Interaction | 53 | 20 | -- |
| Allowable Increment | 512 | 91 | 20 |
| Particulate Matter | | | |
| MCC Point of Maximum Impact | NA[b] | 16 | 2 |
| MCC and FPL Manatee Interaction | NA | 9 | -- |
| MCC and IMC Interaction | NA | -- | -- |
| MCC and AGRICO Interaction | NA | 7 | -- |
| Allowable Increment | NA | 37 | 19 |

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[a] The short-term impacts represent highest, second-highest concentrations.

[b] NA = Not Applicable

Source: Environmental Science and Engineering, Inc., 1981a.

TABLE III-7

## COMPARISON OF ESTIMATED ATMOSPHERIC EMISSIONS, MCC COMPLEX AT ONA

| | | BACT EMISSIONS[a] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Proposed Action | | Alternative 1 Dry Rock at Pascagoula | | Alternative 1 Process Wet Rock | |
| Facility | Pollutant | lb/hr | TPY | lb/hr | TPY | lb/hr | TPY |
| Rock Dryer | PM | 20.28 | 88.83 | — | — | — | — |
| | $SO_2$ | 286.13 | 1,253.25 | — | — | — | — |
| | $NO_x$ | 78.30 | 342.95 | — | — | — | — |
| | CO | 6.75 | 29.57 | — | — | — | — |
| | HC | 1.35 | 5.91 | — | — | — | — |
| Boiler 1 | PM | 1.33 | 5.82 | 1.33 | 5.82 | 1.33 | 5.82 |
| | $SO_2$ | 18.36 | 80.42 | 18.36 | 80.42 | 18.36 | 80.42 |
| | $NO_x$ | 3.02 | 13.23 | 3.02 | 13.23 | 3.02 | 13.23 |
| | CO | 0.26 | 1.14 | 0.26 | 1.14 | 0.26 | 1.14 |
| | HC | 0.05 | 0.22 | 0.05 | 0.22 | 0.05 | 0.22 |
| Boiler 2 | PM | 0.79 | 3.46 | — | — | — | — |
| | $SO_2$ | 10.94 | 47.92 | — | — | — | — |
| | $NO_x$ | 1.80 | 7.88 | — | — | — | — |
| | CO | 0.16 | 0.70 | — | — | — | — |
| | HC | 0.03 | 0.13 | — | — | — | — |
| Dry Rock Storage Transport and Handling | PM | 14.24 | 62.32 | — | — | — | — |
| | $SO_2$ | — | — | — | — | — | — |
| | $NO_x$ | — | — | — | — | — | — |
| | CO | — | — | — | — | — | — |
| | HC | — | — | — | — | — | — |
| Temporary (Site Preparation and Construction) | PM | 21.94 | 4.96 | 21.94 | 4.96 | 21.94 | 4.96 |
| | $SO_2$ | 9.40 | 2.15 | 9.40 | 2.15 | 9.40 | 2.15 |
| | $NO_x$ | 159.87 | 36.49 | 159.87 | 36.49 | 159.87 | 36.49 |
| | CO | 175.43 | 40.08 | 175.43 | 40.08 | 175.43 | 40.08 |
| | HC | 31.35 | 7.15 | 31.35 | 7.15 | 31.35 | 7.15 |
| | Fugitive Dust | 86.20 | 19.68 | 86.20 | 19.68 | 86.20 | 19.68 |
| Mining and Wet Rock Storage | PM | 1.83 | 0.42 | 1.83 | 0.42 | 1.83 | 0.42 |
| | $SO_2$ | 12.07 | 2.76 | 12.07 | 2.76 | 12.07 | 2.76 |
| | $NO_x$ | 24.45 | 5.58 | 24.45 | 5.58 | 24.45 | 5.58 |
| | CO | 7.84 | 1.79 | 7.84 | 1.79 | 7.84 | 1.79 |
| | HC | 1.73 | 0.40 | 1.73 | 0.40 | 1.73 | 0.40 |
| | Fugitive Dust | 298.89 | 68.31 | 298.89 | 68.31 | 298.89 | 68.31 |
| Total | PM | 42.02 | 184.20 | 6.71 | 29.59 | 6.71 | 29.59 |
| | $SO_2$ | 320.34 | 1,403.06 | 23.27 | 101.89 | 23.27 | 101.89 |
| | $NO_x$ | 125.19 | 548.38 | 45.09 | 197.55 | 45.09 | 197.55 |
| | CO | 49.04 | 214.68 | 42.13 | 184.41 | 42.13 | 184.41 |
| | HC | 8.98 | 39.34 | 7.60 | 33.30 | 7.60 | 33.30 |
| | Fugitive Dust | 87.99 | 385.09 | 87.99 | 385.09 | 87.99 | 385.09 |

---

[a] Represents emissions considering control devices (BACT) and the actual operating time in the permit.

## TABLE III-8

## COMPARISON OF APPROXIMATE AIR EMISSIONS FROM PRIMARY SOURCES MCC PASCAGOULA

| Facility | Pollutant | Alternative 1 Dry Rock at Pascagoula[a] | | Alternative 2 Process Wet Rock[b] | |
|---|---|---|---|---|---|
| | | lb/hr | TPY | lb/hr | TPY |
| Rock Dryer | PM | 7 | 30 | -- | -- |
| | $SO_2$ | 95 | 420 | -- | -- |
| | $NO_x$ | 26 | 110 | -- | -- |
| | CO | c | c | -- | -- |
| | HC | c | c | -- | -- |
| Boiler to furnish steam for water evaporation | PM | -- | -- | 20 | 90 |
| | $SO_2$ | -- | -- | 270 | 1,200 |
| | $NO_x$ | -- | -- | 75 | 330 |
| | CO | -- | -- | c | c |
| | HC | -- | -- | c | c |

---

[a] Approximately one-third of Ona mine site rock dryer emissions.

[b] Based on fuel oil sulfur content of two percent by weight.

[c] Less than USEPA significant emissions rates (100 TPY for CO and 40 TPY for HC).

## TABLE III-9

## COMPARISON OF CALCULATED AIR QUALITY EFFECTS FOR THE PROPOSED AND ALTERNATIVE ACTIONS

Page 1 of 2

| | Concentrations ($\mu g/m^3$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ambient Background[b] | | | Calculated MCC Maximum Impact | | | Calculated Plus Background | | |
| | 3-Hr | 24-Hr | Annual | 3-Hr | 24-Hr | Annual | 3-Hr | 24-Hr | Annual |
| **PROPOSED ACTION** | | | | | | | | | |
| **Ona Mine[a]** | | | | | | | | | |
| PM | -- | 90 | 28 | -- | 16 | 2 | -- | 106 | 30 |
| $SO_2$ | 157 | 69 | 4 | 168 | 41 | 6 | 315 | 110 | 10 |
| $NO_x$ | -- | -- | -- | -- | -- | 1 | -- | -- | -- |
| **Pascaguola Site** | | | | | | | | | |
| No change from present conditions. | | | | | | | | | |
| **ALTERNATIVE ACTIONS - ALTERNATIVES 1 AND 2** | | | | | | | | | |
| **Ona Mine[a]** | | | | | | | | | |
| PM | -- | 90 | 28 | -- | 1 | <1 | -- | 91 | 28 |
| $SO_2$ | 157 | 69 | 4 | 9 | 2 | <1 | 166 | 71 | 4 |
| $NO_x$ | -- | -- | -- | -- | -- | <1 | -- | -- | -- |
| **ALTERNATIVE 1 - ROCK DRYER AT PASCAGOULA** | | | | | | | | | |
| **Pascagoula Site[c]** | | | | | | | | | |
| PM | -- | 105 | 40 | -- | -- | -- | -- | -- | -- |
| $SO_2$ | 270 | 90 | 20 | 150 | 40 | 5 | 450[c] | 150[c] | 25[c] |
| $NO_x$ | -- | -- | 24 | -- | -- | 1 | -- | -- | 25[c] |

TABLE III-9 (Continued)

Page 2 of 2

| | Concentrations ($\mu g/m^3$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ambient Background[b] | | | Calculated MCC Maximum Impact | | | Calculated Plus Background | | |
| | 3-Hr | 24-Hr | Annual | 3-Hr | 24-Hr | Annual | 3-Hr | 24-Hr | Annual |
| **ALTERNATIVE 2 - PROCESS WET ROCK** | | | | | | | | | |
| Pascagoula Site[c] | | | | | | | | | |
| PM | -- | 105 | 40 | -- | d | d | -- | -- | -- |
| $SO_2$ | 270 | 90 | 20 | 260 | 85 | 10 | 550[c] | 200[c] | 30[c] |
| $NO_x$ | -- | -- | 24 | -- | -- | 2 | -- | -- | 30[c] |

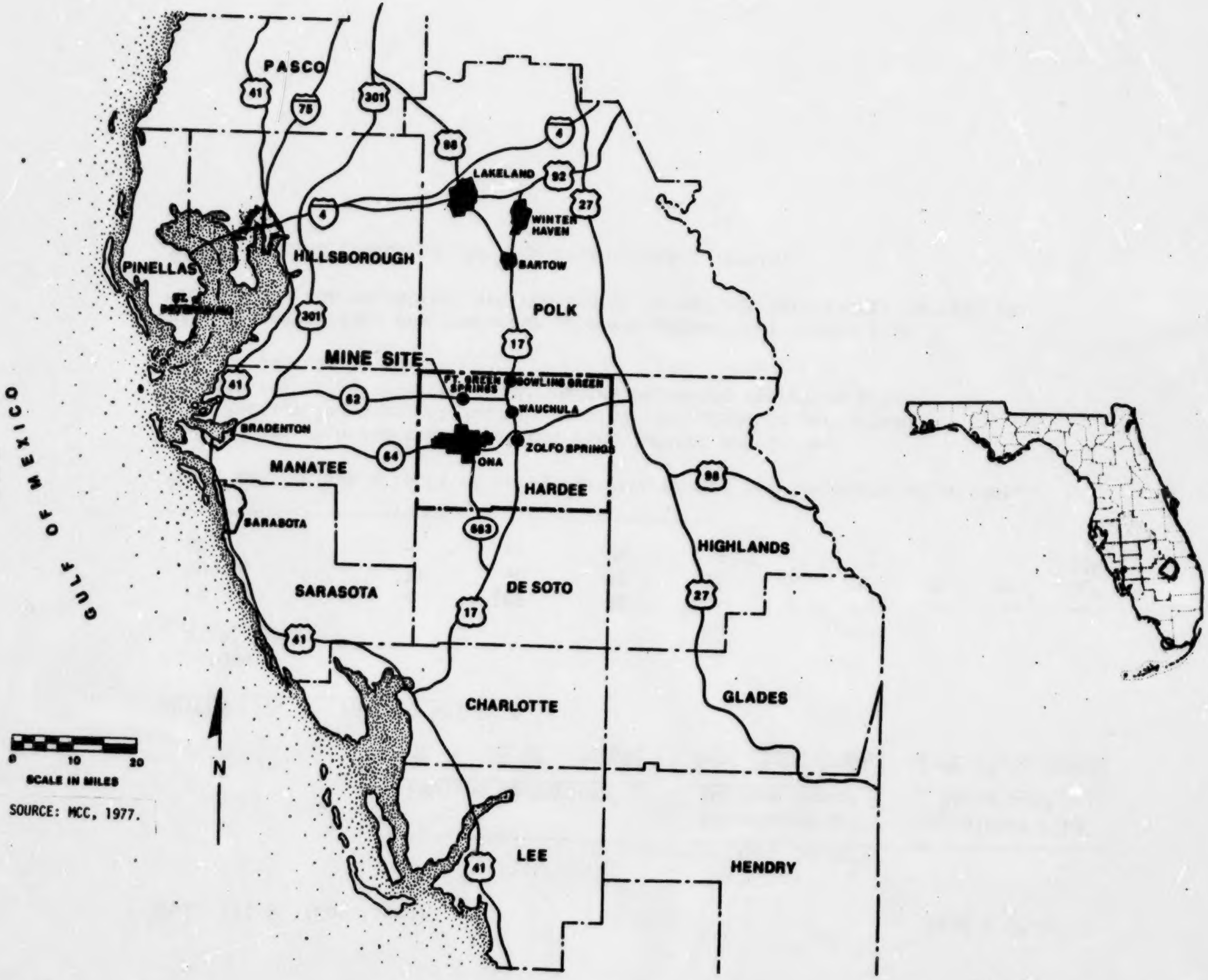
---

[a] Does not include effects of emissions from mining and temporary activities.

[b] Based upon recorded concentrations from ambient monitoring. For Pascagoula, does not include possible increases in background levels resulting from other new sources beginning operation prior to new sources at MCC.

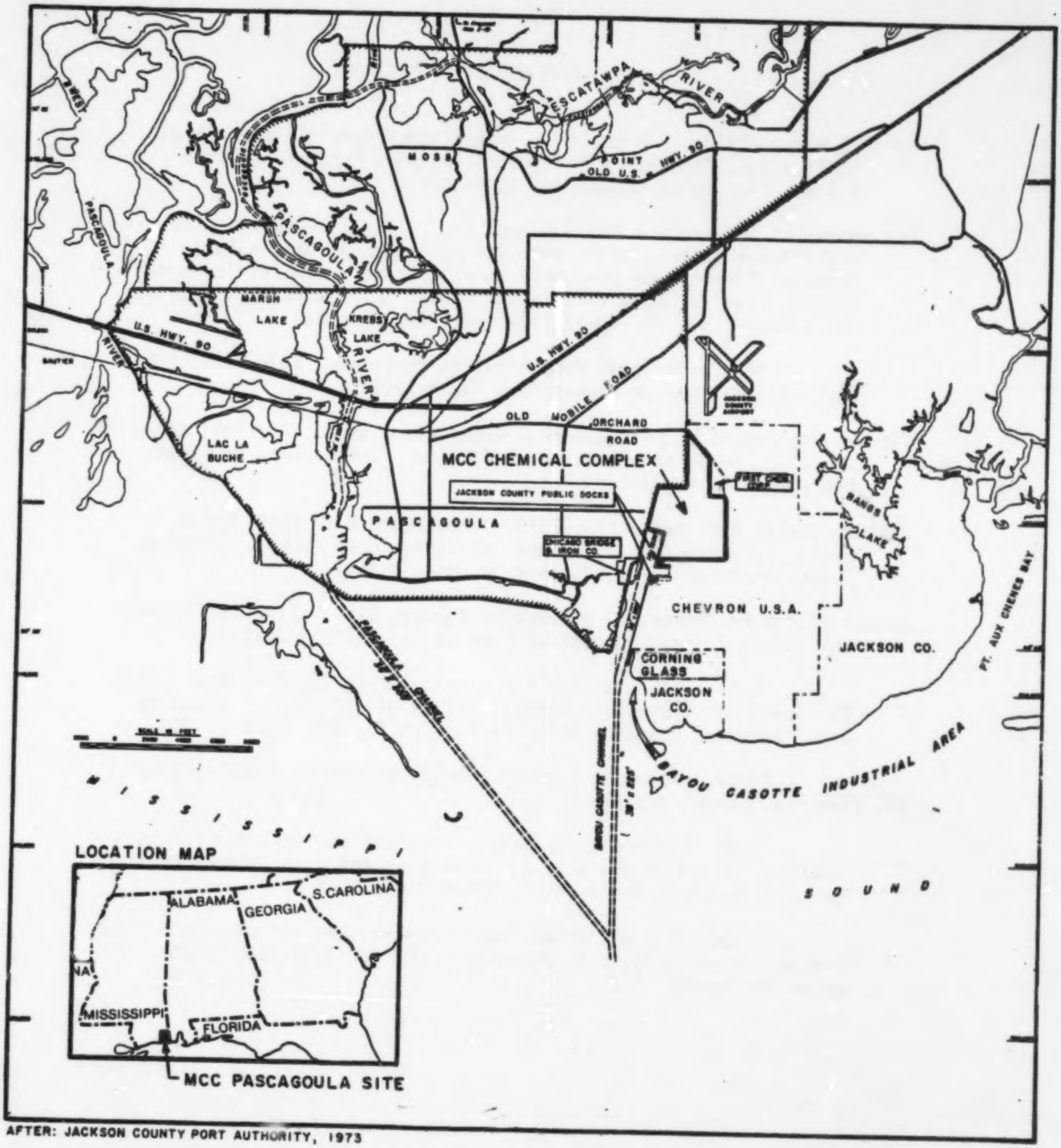
[c] All concentrations are tentative approximations. Calculated plus background concentrations are rounded up to reflect uncertainty in results.

[d] Insignificant (based on EPA significant impact levels).


GULF OF MEXICO
PASCO
PINELLAS
ST. PETERSBURG
HILLSBOROUGH
POLK
MINE SITE
LAKELAND
WINTER HAVEN
BARTOW
FT. GREEN SPRINGS
BOWLING GREEN
WAUCHULA
ZOLFO SPRINGS
ONA
BRADENTON
MANATEE
SARASOTA
SARASOTA
HARDEE
DE SOTO
HIGHLANDS
CHARLOTTE
GLADES
LEE
HENDRY
41
75
301
98
4
92
27
17
62
64
663
N
0
10
20
SCALE IN MILES

SOURCE: MCC, 1977.

Figure III-1. MCC Site Location.


ESCATAWPA RIVER
MOSS POINT
OLD U.S. HWY. 90
PASCAGOULA
PASCAGOULA RIVER
WEST PASCAGOULA
MARSH LAKE
KREBS LAKE
RIVER
U.S. HWY. 90
U.S. HWY. 90
OLD MOBILE ROAD
ORCHARD ROAD
LAC LA BUCHE
MCC CHEMICAL COMPLEX
JACKSON COUNTY PUBLIC DOCKS
PASCAGOULA
CHICAGO BRIDGE & IRON CO.
JACKSON COUNTY AIRPORT
CHEVRON U.S.A.
JACKSON CO.
CORNING GLASS
JACKSON CO.
BAYOU CASOTTE INDUSTRIAL AREA
BAYOU CASOTTE CHANNEL
PASCAGOULA CHANNEL
BANGS LAKE
PT. AUX CHENES BAY
MISSISSIPPI SOUND
SCALE IN FEET
LOCATION MAP
ALABAMA
GEORGIA
S. CAROLINA
MISSISSIPPI
FLORIDA
MCC PASCAGOULA SITE

AFTER: JACKSON COUNTY PORT AUTHORITY, 1973

Figure III-2. Location of Mississippi Chemical Corporation's Pascagoula Chemical Complex.

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__________, 1978b. Source assessment: chemical and fertilizer mineral industry, state of the art, J. C. Ochsner and T. R. Blackwood, Monsanto Research Corporation, EPA-600/2-78-004 p.

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# TECHNICAL SUPPORT DOCUMENT IV

# HUMAN RESOURCES

# IV HUMAN RESOURCES

## 1.0 SOCIOECONOMICS AND TRANSPORTATION

### 1.1 EXISTING CONDITIONS

The seven-county region selected for study includes Charlotte, DeSoto, Hardee, Hillsborough, Manatee, Polk, and Sarasota Counties (Figure III-1). These counties were grouped for study due to the presence of phosphate reserves and the influence that mining of these reserves may have on the counties' socioeconomic characteristics. These counties were also in the region defined by the Central Florida Phosphate Industry Areawide Impact Assessment (USEPA, 1978).

### 1.1.1 Population

The population within the seven-county region is shown on Table IV-1 for 1970, 1975, and 1979. The region grew at the same rate as Florida, 3.6 percent annually, for the nine-year period. Compound growth rates for both the seven-county area and the state were twice as high between 1970 and 1975 (4.6 percent annually) as they were during the last four years (2.3 percent annually). Local planners believe that poor economic conditions between 1975 and 1980 caused the recent slowdown in population growth. Retirees and working people did not enter the state or study region at a rate as high as they did between 1970 and 1975. Compound growth rates were particularly high in Charlotte and Sarasota Counties between 1970 and 1979. These are the most popular retirement counties in the study area. Hardee County grew slowly, only 2.4 percent annually between 1970 and 1979, due to a lack of employment opportunities in the county (Ford, 1980).

The populations which are projected for the state, region, and individual counties through the year 2000 are shown in Table IV-2. Future population growth in the study region is expected to be less than the growth between 1970 and 1979 because immigration is anticipated to occur at a rate more similar to that of the 1975-1979 period than to that of the 1970-1975 period. The population in the study region is expected to continue to grow at the same rate as the state population, 1.8 percent annually. Popular retirement counties are still expected to experience the region's greatest amount of growth while Hardee County is expected to grow at a slower annual rate than any of the other counties in the region.

### 1.1.2 Employment

Employment and unemployment statistics for 1979 and the unemployment rate for July 1980 are shown in Table IV-3. During 1979, agricultural counties such as Hardee and DeSoto had unemployment rates that were higher than the study region and state averages; unemployment was 8.0 percent and 6.5 percent for these respective counties, compared to 5.9 percent for the study region and 6.0 percent for the state average. Polk County also had a high unemployment rate because of the presence of a large number of workers who are employed there on a seasonal basis. In counties that have a high number of retirees, such as Charlotte, Manatee, and Sarasota, the unemployment rates were lower than they were in the remainder of the study region.

Due to the seasonal nature of agriculture in the region, unemployment rates in July 1980 were higher than the average rates in 1979 for all of the counties in the study region. Many of the local farm crops, citrus in particular, as well as cucumbers and other truck crops, are ready for harvesting and processing in the fall and winter. Employment is relatively high during these seasons, but there is a correspondingly high unemployment rate during off-season periods. The unemployment rate for the region increased from 5.9 percent for the 1979 average to 8.5 percent in July 1980. Unemployment in Hardee County increased from 8.0 percent as the 1979 average to 12.1 percent for July 1980.

Employment by industry for the study region in 1973 and 1978 is shown in Table IV-4. This table shows the importance of each industry to the economy of the region and the percent change in total employment by industry between 1973 and 1978. Although employment increased by almost 81,600 between 1973 and 1978, the percentage of total employment by industry changed very little. For example, the percentage of total employment remained the same in six of the ten industries listed while employment in the remaining four industries shifted by only 1 percent between 1973 and 1978. Table IV-5 shows the leading employment sectors in each county of the study region during 1973 and 1978. Trade ranked first in the study region, with 23 percent of total employment during both 1973 and 1978. Services, the second largest source of employment in the study region, accounted for 18 percent of total employment in 1978 and 17 percent in 1973 while government accounted for 15 percent of total employment during both years. Government is a particularly large employer in DeSoto County due to the presence of a state mental hospital, a state correctional institute, and a state road prison.

Manufacturing is a major employer in Polk, Hillsborough, and Manatee Counties, where this sector accounted for between 13 and 16 percent of total employment in 1973 and 1978. Manufacturing has remained a stable portion of total employment in the study region but is not expected to increase rapidly in the next five years (Ford, 1980).

In comparison with other counties in the study region, Hardee County has a higher portion of its employment in agriculture. Citrus (especially oranges) is the most important agricultural product of the county, followed by livestock and small amounts of truck crops such as cucumbers and melons. The contribution of agricultural employment has declined somewhat in the past five years, decreasing from 33 percent of total employment in 1973 to 29 percent in 1978. A major change occurred between 1973 and 1978 in Hardee County employment in the "Other" category, which includes the Bureau of Economic Analysis categories of mining and "agricultural services, forestry, fisheries, and other." This category increased from 4 percent of total employment in 1973 to

14 percent in 1978. This increase was due to increases in employment at various agriculturally-related plants in the county: Parker Farms expanded their vegetable processing plant; American Agronomics expanded their agricultural chemical plant; and American Orange added a new plant in Hardee County between 1973 and 1978 (Peele, 1980). In addition, CF Industries started their phosphate mine, the first mine in Hardee County, in 1977. The exact number of employees who work at the CF Industries mine is not available, but Stallings (1980), a CF representative, indicated that there currently are fewer than 200 employees at the mine. Thus, employment in mining increased in the county from 0 to something less than 200 between 1973 and 1978. Other important employers in the county during 1978 were government, with 15 percent of total employment, and trade, with 14 percent of total employment.

There are few employment statistics for the mining industry in the study area. The best available information is the number of mining and chemical employees by place of residence (Table IV-6). Active mines are currently located in Hillsborough, Polk, and Hardee Counties, and a small pilot project is operating in DeSoto County (Ford, 1980). In 1979, mining and chemical employment accounted for roughly 1 percent, 6 percent, and 10 percent of the nonagricultural work force living in Hillsborough, Polk, and Hardee Counties, respectively.

In the future, it is expected that, as existing mines exhaust their phosphate reserves, new mines will be opened in Hillsborough, Polk, DeSoto, and Hardee Counties (Tubbs, 1980). In general, the mining industry is expected to move slowly southward in the next 10 years.

### 1.1.3 Personal Income

The counties in the study area vary as much by income as they do by employment. Except for Sarasota County, all of the counties in the study region were below average U.S. per capita income levels in 1978 (Table IV-7). Small rural counties such as Hardee and DeSoto had the lowest income levels in the region, with 88 percent and 83 percent of the U.S. average income in 1978, respectively. Sarasota County had 119 percent of the U.S. average income level due to the presence of numerous wealthy retirees who bring income payments into the county (USEPA, 1979). Charlotte and Manatee Counties, also areas with a large number of retirees, have per capita incomes that are close to the national average.

Per capita income in all of the counties of the study area rose faster than the national average during the period between 1969 and 1978 (Table IV-7). The six counties below per capita national income all increased toward the national average during this period. In general, the geometric rate of change of the per capita personal income for the counties in the study area was approximately 10 percent between 1969 and 1978; the geometric rate of change for the U.S. was 8.8 percent during the same period.

Farm income is an important part of the total income in Hardee and DeSoto Counties, representing 32 percent and 17 percent of the total income in these respective counties in 1978 (Table IV-8). Other counties in the region derive a much smaller portion of their total income from the agricultural sector, with the average farm income being only 3 percent of the regional total.

### 1.1.4 Basic and Nonbasic Industries

The growth of a region depends to a significant extent on the demand for goods and services exported to other sections of the country. Exported goods and services bring income into the region which is then spent and respent on goods and services produced in the local business sector.

Location quotients, a measure of local employment relative to total U.S. employment, can be used to identify export and local sectors of the economy (Isard, 1973). A location quotient between 0.91 and 1.20 for an industry suggests that the region is generally self-sufficient in that industry. A coefficient above 1.20 identifies export industries; a coefficient below 0.91 indicates that goods and services produced by these industries in the region are insufficient to meet the local demand and that these products are, therefore, being imported. Typically, in rural counties, a low coefficient means the residents are shopping in market centers outside of the county. As shown in Table IV-9, the location quotient is greater than 1.20 in the study region in construction, non-farm proprietors' employment, and "other" employment. The location quotient for Hardee County is greater than 1.20 in agriculture, non-farm proprietors' employment, and "other." The large location quotient for "other" is due to the large amount of agricultural services.

### 1.1.5 Community Services and Facilities

The Central Florida Phosphate Industry Areawide Impact Assessment (USEPA, 1978) describes the services and facilities in the study region, and the ADA/DRI's for MCC (MCC, 1977) as well as other phosphate industries in the area (CF Mining Corporation, 1976) contain detailed descriptions of Hardee County services and facilities. Facilities and services in the study region and in Hardee County are currently at adequate levels for the existing population (MCC, 1977). Local planners expect that facilities and services will remain adequate through 1985 (Ford, 1980). However, housing vacancy rates in Hardee County declined (Table IV-10) from 7.0 percent in 1970 to an estimated 3.5 percent in 1976 (Central Florida Regional Planning Council [CFRPC], 1978). This decline in available units is attributed to housing starts that did not keep pace with the growth that occurred in Hardee County during the period. Based on housing levels considered to be adequate vacancy rates for a growing community, the CFRPC (1978) projected a higher housing vacancy rate of 6.2 percent in 1980. Because available housing in Hardee County is not expected to meet the demand in the 1980's, workers are expected to commute to the project site rather than attempt to find housing in Hardee County (Ford, 1980).

### 1.1.6 Transportation

Three roads are expected to receive the bulk of the traffic which will result from the MCC project. These roads are US 17 (also designated as State Road 35), State Road (SR) 62, and SR 64. These roads are shown in relation to the mine site on Figures III-1 and IV-1.

#### US 17/State Road 35

This road is classified as a primary north/south arterial. It runs between US 41 on the Gulf coast of Charlotte County and US 92 near the urban areas in Polk County. It connects Charlotte, DeSoto, and Hardee Counties to central Florida and the Gulf coast. Highway segments from Bowling Green to the Hardee/DeSoto County line are two-lane and four-lane, with the four-lane segments occurring mainly in the incorporated areas of Bowling Green, Wauchula, and Zolfo Springs. The four-lane segment relieves urban congestion and increases traffic flow at major intersections. Those segments of US 17 between Bowling Green and Wauchula and between Wauchula and Zolfo Springs are tentatively scheduled to be expanded to four lanes by 1985, if sufficient funds are available (Swagerman, 1980).

Most sections of US 17 currently provide operational levels of service C or higher (see Table IV-11 for service level definitions), but two sections, one between Wauchula and Zolfo Springs and the other between Wauchula and the intersection of SR 62, are presently operating at level D. These two sections total 6.5 miles and are scheduled to be upgraded to four lanes by 1985, resulting in a level of service of A and B, respectively. The section of US 17 between Bowling Green and SR 62 has not been scheduled to be upgraded to four lanes. By 1985, the service level of this segment is expected to have decreased from C to D.

### State Road 62

State Road 62 is a two-lane minor east/west arterial. It intersects US 17 near the city limits of Wauchula. Levels of service along the highway range from A to B and are expected to remain at the B level through 1985, with peak hour traffic loads no greater than 300 vehicles per hour (VPH).

### State Road 64

State Road 64 is the main road from US 17 at Zolfo Springs to Bradenton in Manatee County; it passes through Ona and intersects the MCC property. This road is classified as a two-lane minor arterial. Current average daily traffic levels vary between 1,448 vehicles per day (VPD) and 3,447 VPD, with traffic volumes increasing near US 17 and around Zolfo Springs. Estimated peak hour traffic flows range from 217 to 517 VPH and are not expected to exceed 635 VPH in 1985. Truck traffic along this highway is substantial. SR 64 is presently operating at a satisfactory level of service and is expected to remain at this level through 1985.

## 1.2 ENVIRONMENTAL IMPACTS

Project alternatives under consideration would have the same effect on the number of workers who will work on the project or the location from which these workers will be drawn. Because the number of new workers and their place of origin are the factors that influence socioeconomics and transportation, implementation of any of the project alternatives would have a similar impact on these characteristics. Impacts which would occur as a result of any of the project alternatives discussed in Section 2.0 of the DEIS are presented below.

### Population and Employment

Construction of the proposed facility would take about two years. During this time, it is estimated that an average of 350 workers would be employed. Peak construction employment would range between 630 and 700 workers (Table IV-12) and would occur during the latter part of the first year, extending for several months into the second year. The operational phase would provide full-time employment for up to 450 people. (MCC, 1977).

Since the seven-county region has been extensively involved in phosphate mining for several years, most of the necessary skills and equipment can be found in the region. Ninety percent of the work force in both the construction and operating phases would come from the study region; 50 percent of the total would be derived from Hillsborough County, 30 percent from Polk County, and 10 percent from Hardee County. The remaining 10 percent would come from Pinellas County, which is not included in the study region (MCC, 1977). Assuming an average household size of 2.87 people (CFRPC, 1978), if all of the workers from outside the study region bring their families (maximum of 70 workers), the seven-county region would experience a maximum increase of about 200 people during the peak construction period.

Some of the necessary workers would come from other jobs within the area because mining employment pays relatively high wages; some would come from the ranks of the unemployed. In either case, direct employment in both phases of the project would account for less than 1 percent of projected 1985 employment in the study region, and less than 2 percent of projected 1985 employment in Hardee County.

In addition to the direct impacts of a peak of 630 construction workers and 410 operational workers in the study region, there would be indirect and induced employment impacts from the MCC project. Indirect impacts would result from the additional employment generated from sales of goods and services to the phosphate industry by a succession of suppliers. Induced impacts are the result of the wages and salaries paid to employees of the phosphate industry that are then spent on consumer goods in the economy, leading to additional employment in these consumer goods industries.

The multipliers used to calculate indirect and induced employment figures are estimates calculated by Wang and others (1974) in their expanded table of the U.S. economy, modified to reflect only the State of Florida. Impact estimates calculated with these employment multipliers indicate the magnitude of the impact. Estimated direct, indirect, and induced employment increases in the study region as a result of the MCC project are as follows:

| Study Region | Construction | Operation |
|---|---|---|
| Direct Impacts | 630 | 410 |
| Indirect Impacts | 460 | 300 |
| Induced Impacts | 2,790 | 1,820 |
| Total Impacts | 3,880 | 2,530 |

## Personal Income

The personal income that is received by the project workers would increase projected personal income in 1985 by less than 1 percent in the study region and in Hardee County (Table IV-12).

The MCC project would also have indirect and induced impacts on the income of the study region in addition to the direct effects resulting from salaries paid to project workers. Indirect and induced impacts on income would result from the wages paid to workers holding jobs indirectly created or induced as the result of the MCC project.

Using income multipliers derived from the same source as those used to estimate induced and indirect employment, the following direct, indirect, and induced income increases in the study region were derived:

| Study Region | Construction | Operation |
|---|---|---|
| | (To the nearest $10^5$ dollars) | |
| Direct Impacts | \$12.6 | \$5.4 |
| Indirect Impacts | 6.9 | 2.9 |
| Induced Impacts | 22.9 | 9.8 |
| Total Impacts | 42.4 | 18.1 |

## Project Expenditures

Construction expenditures for the study region and Hardee County are shown in Table IV-13. The construction phase of the project would involve the expenditure of about \$47.5 million annually for two years. Assuming that total construction expenditures would accrue to the study area and Hardee County in proportion to the expenditures for labor, then 90 percent of the total construction expenditures would accrue to the seven-county region, and 10 percent of the total would be spent in Hardee County. Based on this assumption, about \$42.7 million would go to counties in the study region on an annual basis and \$4.3 million of this total regional expenditure would accrue to Hardee County during each year of the construction phase. The remaining annual construction expenditures would be spent outside of the study region.

Expenditures during the operational phase of the project would be distributed in the same manner as during the construction phase. Thus, it is estimated that from expenditures totalling about \$27 million annually (MCC, 1977), about \$24.3 million, or 90 percent, would be spent in the study region, and \$2.4 million, or 10 percent of the regional total, would be spent in Hardee County annually.

## Community Services

Population changes in the study region and in Hardee County due to the project are expected to be small (Table IV-12). Because housing availability is currently low in Hardee County and is expected to remain low into the 1980's (Table IV-10), most workers are expected to commute to the project site rather than attempt to find housing in Hardee County (Ford, 1980). It is also likely that there would be little change in housing patterns among counties in the study region as a result of implementation of the MCC project.

Related to Hardee County's ability to provide community services is the tax revenue which would accrue to the county. Mississippi Chemical Company has negotiated an assessed value of $2,800 per acre for the 14,850 acres. Using a tax rate of 10.02 mills per acre, the taxes which would be paid to Hardee County are $415,600 per year. This income is about 180 percent more tax than the land would generate as agricultural land. Not all of the land would be mined, and after mining and reclamation, the value of the land would change. Mississippi Chemical Company may apply for Green Belt exemptions for such land. However, as much of the reclaimed land would be improved pasture, higher taxes would accrue to the county in the future than if this land remained as native rangeland.

Since population changes in the study region and in Hardee County due to the MCC project are expected to be minor, and because community facilities and services in the study region and Hardee County are adequate for existing and projected 1985 population, the MCC project is not expected to strain facilities or services in any of the communities of the study region.

## Transportation

A thorough transportation analysis of the plant's normal highway flows and how these flows would affect the highway system is found in the ADA/DRI for this project (MCC, 1977). Although some car pooling can be expected, this 1977 analysis assumed that all workers would arrive in individual cars (worst case), adding a total of 700 vehicles to the traffic levels projected for 1985 without the project. It is expected that 50 percent of the work force traffic would originate in

Hillsborough County, 30 percent in Polk County, 10 percent from Hardee County, and 10 percent from Pinellas County (MCC, 1977). Based on the expected routes that this work force would prefer, it is estimated (MCC, 1977) that 50 percent of the employees would arrive on SR 62 west of Fort Green Springs, 15 percent on SR 64 west of Ona, and 35 percent would utilize US 17 from Zolfo Springs.

The estimated peak hour traffic levels for 1985, both with and without the project, are shown in Table IV-14. Peak traffic levels are expected to exceed the 1985 road capacity only on US 17. Even with the proposed four-laning of US 17, the added traffic that would result from the project would increase traffic levels by about 13 percent above the projected 1985 capacity. If funding for the proposed four-laning is not available, the expected levels of service along this highway may drop below satisfactory levels. The service level on one portion of US 17 just south of Bowling Green and north of SR 62 is expected to fall to Service Level D. However, the service level along this particular section is expected to drop from C to D even without the traffic generated by the proposed project, and the additional load would not cause the service level to fall below level D. However, there would be some congestion on this section of the highway.

Portions of Vandolah Road and all of the Fort Green-Ona road (Figure IV-1) are unpaved at present. Since these would be major access roads to the plant, their unpaved condition may cause some congestion near the plant entrance. Although this would have very little effect on the traffic flow in the county, it could result in congestion for employees during the construction and operation phases of the project. As specified in the Development Order (Appendix C) MCC would coordinate with Hardee County, the Florida Phosphate Council, and other phosphate companies planning to mine in the area to upgrade the Fort Green-Ona Road and Vandolah Road.

Another potential effect on transportation systems would arise from movement of phosphate rock from the mine to Tampa for subsequent barge shipment. Assuming 70 cars per train and a capacity of 80 tons of dry rock per car, each train could carry 5,600 tons of rock. At a production rate of 3 million tons per year, the mine would require approximately 535 train loads per year, or about three trains every two days. At Tampa, the trains would be off-loaded for temporary rock storage, and the rock would be loaded onto barges (approximately 19,000-ton capacity). Thus, approximately 160 barges would be required per year, or an average of one every 2.3 days. Neither the rail nor barge traffic should cause significant congestion or traffic hazards by itself though cumulative congestion in rail yards in the Tampa area due to transport of rock from several mines might cause occasional rail delays.

If significant difficulties should be encountered with rail car availability or with train movements, MCC might use trucks to move the phosphate rock. At the average rate of rock production, 430 truck loads per day (assuming 20 tons per truck) would be required. Clearly, this is an excessive amount of truck traffic for local roads. Trucks can be relied on only for spot deliveries of phosphate rock.

## 1.3 MITIGATIVE MEASURES

Because effects of the project impacts on employment and personal income are expected to be positive in nature, mitigative measures for socioeconomic impacts are not considered applicable.

No measures to mitigate traffic impacts appear necessary during periods of construction activities when maximum work force levels would be required. Hence, no mitigative measures would be needed during periods of average construction or operation activity. However, if traffic problems develop during peak construction periods, staggering work shifts would decrease traffic in the plant vicinity. Under such a program, the arrival and departure times of the construction personnel could be spread over a one- or two-hour period, allowing traffic flows to be maintained at a level compatible with normal flows. Paving of the Fort Green-Ona road and unpaved portions of Vandolah Road would also contribute to improved traffic conditions in the plant vicinity.

## 2.0 LAND USE

### 2.1 EXISTING CONDITIONS

### Regional

Land use patterns in the seven counties which comprise the region in which the MCC site is located are discussed in the Central Florida Phosphate Industry Areawide Impact Assessment (USEPA, 1978). Therefore, the discussion in this document will focus on land use patterns of Hardee County and the site.

### Hardee County

Land in Hardee County is used primarily for agricultural purposes. As shown on Table IV-15, more than 75 percent of the county is in citrus, pasture, rangeland, or cropland, while only about 1 percent of the county is urbanized. Urban uses are concentrated along US 17 and include the incorporated areas of Bowling Green, Wauchula, and Zolfo Springs.

The largest use of land in the county is rangeland, occupying almost 36 percent of the total county land area. Other significant uses include cropland and pasture (26 percent), citrus groves and nurseries (17 percent), and wetlands (17 percent). Mining uses were insignificant in 1975.

Citrus is by far the leading farm product in the county, followed by livestock. The orange crop was valued at between $65 and $75 million in the 1978 to 1979 season; cattle sales were valued at between $10 and $15 million in 1979 (Hayman, 1980).

Table IV-16 indicates generalized land uses in Hardee County for 1975 and projected land uses to the year 2035. The table indicates that the only increase in land use will occur in the urban and built-up category. This use will increase from 1.14 percent of the study area in 1975 to 2.06 percent in the year 2000 and 2.97 percent by 2035.

Much of the increase will occur in the residential category; an increase of 2,362 acres, or almost 68 percent, is projected to occur in the residential category between 1975 and 2000.

Land used for residential, commercial services, and other urban purposes is expected to increase substantially between 1975 and 2000 due to anticipated expansion of the phosphate industry and the associated economic growth. The land expected to be converted to these uses is now agricultural and rangeland, which will experience small percentage declines between 1975 and 2000 (Table IV-16).

There are no projections of land expected to be mined for phosphate rock in Hardee County. The holdings of phosphate companies in 1975 provides the best indication of the total amount of land which might be mined and reclaimed by the year 2035 (Figure IV-2). The total area is roughly one-third of the county, or about 135,000 acres. Land currently permitted for mining totals about 25,000 acres (Figure IV-2). MCC proposes to mine, or store waste on, an additional 12,000 acres. Development of the remaining land shown to contain phosphate holdings is speculative. Mining on these lands would occur on areas presently used for crops and pasture, citrus groves, rangeland, and forest. These pastures and rangelands would be diverted to mining uses and restored for cattle and pasture areas over the planning period.

Site

The MCC property accounts for almost 4 percent of the county's total land area. The existing percentage of land use or land cover on the MCC site and in Hardee County, based on USGS Land Use and Development Analysis (LUDA) categories, is indicated below (MCC, 1977):

| Land Use Type (LUDA #) | Approximate Area (Acres) on Site | Approximate Percent of Site |
|---|---|---|
| Pasture (210) | 5,040 | 34 |
| Citrus Grove (230) | 28 | <1 |
| Pine Flatwood, Palmetto, Forest Rangeland (411) | 6,002 | 40 |
| Xeric Hammock (421) | 30 | <1 |
| Hardwood Swamp (621) | 490 | 3 |
| Mesic Hammock (422) | 770 | 5 |
| Fresh Water Marsh (641) | 2,490 | 17 |
| Urban (100) | 0 | 0 |
| Total | 14,850 | 100 |

A comparison of the proportional land uses on the MCC property and in Hardee County is shown below:

| Land Use Type (LUDA #) | MCC Site (Percent) | Hardee County (Percent) |
|---|---|---|
| Pasture (210) | 34 | 26 |
| Citrus Grove (230) | <1 | 17 |
| Rangeland (411) | 40 | 36 |
| Forest Upland (421, 422) | 6 | 3 |
| Wetlands (621, 641) | 20 | 17 |
| Urban (100) | 0 | 1 |

The percentage of rangeland, forest land, wetlands, and urban land contained on the site is similar to that found elsewhere in Hardee County. The MCC property has a greater percentage of pasture land and an especially low amount of land under cultivation for citrus products in comparison to the county as a whole. Since citrus production is a more intensive land use (more productivity per acre of use) than is cattle grazing, it can be concluded that the MCC site is less productive from an economic standpoint than other areas of the county which specialize in citrus production.

Currently, agricultural usage of the site is limited almost entirely to cattle ranching, but citrus is also produced. In general, there are three types of natural cattle grazing ranges found on the MCC property: pine flatlands, wet prairies, and hammocks. There are also substantial amounts of improved pasture on the site. Table IV-17 shows the acreages and the estimated carrying capacity of each type of range. The potential productivity of the area for this use was calculated using U.S. Department of Agriculture Soil Conservation Service productivity estimates for soils similar to those found on the site. Based on these data, the entire MCC property could support approximately 1,200 to 1,500 head of cattle. Variances in the carrying capacity result from the condition of the range, the degree to which it has been grazed, and management practices. Hence, actual capacity may differ from the data shown on Table IV-17.

Citrus production on the MCC property was calculated in a similar manner. Based on average yields of 300 boxes per acre in Hardee County, the 28-acre citrus grove on the site could produce approximately 8,400 boxes of oranges annually.

There are no significant prime farmland soils on the MCC property, but 28 acres on the property contain a unique soil, as determined by this area's usage for citrus production (Miller, 1980). The grove covers less than 1 percent of the total 14,850 acres.

## 2.2 ENVIRONMENTAL IMPACTS

Table IV-18 shows the maximum possible loss which would occur if 100, 25, or 10 percent of the MCC site were taken out of agricultural production. This table shows the worst-case economic impacts using the higher of 1978 to 1979 prices for both cattle and citrus, $6.50 per box for oranges and $500 per head for cattle. The total maximum annual loss, assuming that 100 percent of the site is removed from agricultural production as a result of the project, is an estimated $655,000 to $805,000. This represents less than 1 percent of the value of total county agricultural production in 1979.

In reality, agricultural losses would not be this high since some of the land would remain in production when other parcels are being mined and reclaimed. Table IV-18 shows maximum annual losses which can be expected if 25 percent or 10 percent of the agricultural land on the MCC site is not available for production in any given year. Assuming that the orange crop would be completely lost in both cases, the crop and livestock losses would be an estimated $115,000 to $130,000 for a 10 percent loss in production and an estimated $205,000 to $243,000 for a 25 percent loss in production. These losses are low when compared to 1979 Hardee County agricultural production. Less than 1 percent of the county citrus crop and no more than 2 percent of county livestock production would be lost due to mining on the MCC site. When compared with statewide or regional agricultural production data, these livestock and citrus losses appear even less significant.

## 2.3 MITIGATIVE MEASURES

Mitigative measures for land use would be undertaken through the reclamation process, as required by local, state, and federal regulations. No significant adverse impacts on land use that would require additional mitigating measures have been identified.

# 3.0 NOISE

## 3.1 EXISTING CONDITIONS

### 3.1.1 Noise Measurement Locations and Measurement Periods

The pre-operational ambient sound levels at the MCC site have been documented in order to assess the impact of the proposed mining operation on noise-sensitive areas. To establish the existing sound quality in the area of the proposed phosphate mine and beneficiation plant, background ambient sound level measurements were made in accordance with ANS S1.13-1971. Measurements were made at various locations (see Figure IV-3) to provide an adequate spatial description of the present environmental sound at representative noise-sensitive locations where the ambient sound levels may be affected by the proposed project.

Location 1 is in the community of Ona, north of State Road 64 (SR64) and east of the Ona-Ft. Green Road, near the railroad. The community is unincorporated and consists of a few grocery stores and service stations, a post office, a lumber yard and less than 50 residences. The sound level measurements were made in an unused lot near the railroad. In relation to the area where the measurements were made, the lumber yard made is across SR64 approximately 100 yards distant. This location is on the westernmost edge of the residences.

Location 2 is at the east property boundary, west of Highway 64A. The station location is in a group of approximately 3 trailers and 4 residences about 200 yards west of the proposed mining property in an orange grove. The dirt road leading to the trailers dead ends approximately 35 yards from the station location.

Location 3 is on Vandolah Road, along the northern property boundary. The location is about 15 yards south of the road's center line in a cow pasture. The nearest residence is across the road approximately 75 yards distant.

Location 4 is at the New Zion Church, North of SR64 on Sidney Roberts Road. The station is located approximately 15 yards east of Sidney Roberts road between the church and a cemetery. The mine property boundary is approximately 75 yards to the east of the location. The nearest residence is across Sidney Roberts road approximately 100 yards distant.

The ambient sound level survey was conducted at the above locations on July 7, 8, and 9, 1980. Sound level measurements were made at each location during the morning (0700-1200), afternoon (1200-1800), evening (1800-2200), and nighttime (2200-0700).

All but one of sixteen recordings of the background ambient sound were 20 minutes in length. Due to a severe thunderstorm, one recording was terminated 8 minutes into the recording.

### 3.1.2 Instrumentation

The data acquisition system consisted of a GenRad omni-directional 1-inch electret condenser microphone with wind screen, a GenRad Type 1933 sound level meter and octave band analyzer, and a Nagra 4.2L single track magnetic tape recorder. The GenRad 1933 sound level meter and octave band analyzer was used as a linear amplifier and step attenuator. Ambient sound was recorded on Scotch 177 magnetic tape. The data acquistion system is shown schematically on Figure IV-4. The equipment used for data acquisition is tabulated in Table IV-19.

Prior to each recording session, the batteries of the sound level meter and tape recorder were checked. The entire system was calibrated before each recording by means of a reference sound level signal at 1000 Hertz and at 114 dB which was generated by a GenRad Type 1562A sound level calibrator.

The tape recorded data were returned to the Dames & Moore acoustic laboratory for analysis using a GenRad Real-time Analyzer and a Digital

Equipment Corporation mini-computer. These equipment are shown schematically on Figure IV-5 and are described in Table IV-20.

Meteorological parameters such as wet bulb and dry bulb temperatures and wind speed were noted during each recording period. High relative humidity (over 90 percent) occurred during the nighttime measurement period. The recording session continued since the microphone appeared to operate (and calibrate) normally. Meteorological conditions observed during the measurement periods are presented in Table IV-21.

### 3.1.3 Noise Sources

During the measurement period, the following listed noise sources were monitored. These sources contributed to the ambient sound levels which are reported in the following section.

Location 1 - Morning - Ona Road and SR64 traffic, chickens, lumber yard work noises.

Afternoon - SR64 and nearby traffic, chickens, voices, tractors, air horn.

Evening - SR64 traffic, chickens.

Night - Cows, dogs barking, aircraft, SR64 traffic.

Location 2 - Morning - Birds, insects, breezes, road traffic, nearby trucks, cows, aircraft.

Afternoon - Birds, insects, breezes, aircraft, chickens, distant thunder, cows, dogs barking, voices, hammering, distant road traffic.

Night - Insects, distant highway traffic, distant cows, frogs, dogs barking, doors slamming, television/musical instrument, aircraft.

Evening - Birds, cows, chickens, distant thunder, distant highway traffic, insects, nearby bees, breezes, doors slamming, voices, distant road traffic.

Location 3 - Morning - Birds, road traffic, aircraft, breezes, bees, distant tractors.

Afternoon - Aircraft, birds, insects, road traffic, cows, wind.

Evening - Distant thunderstorm, cows, birds, voices, road traffic.

Night - Cows, distant dogs barking, distant road traffic, doors slamming, insects.

Location 4 - Morning - Aircraft, birds, breeze, SR64 traffic, road traffic.

Afternoon - Aircraft, birds, breeze, nearby road traffic, distant SR64 traffic, crickets, distant horns.

Evening - Birds, nearby lawnmowers, aircraft, distant thunder, crickets, dogs barking, breeze, distant cows, SR64 traffic, voices, road traffic, doors slamming, church activity.

Night - Crickets, distant cows, frogs, SR64 traffic, distant dogs barking, breeze, aircraft, local residential activity.

### 3.1.4 Results

A summary of the statistical sound levels measured at each survey location is presented in Table IV-22. Measurements taken at midnight at Location 1 and at 1100 hours at Location 4 are considered suspect due to calibration difficulties, although the results appear to be satisfactory. Nomenclature and the detailed results of the ambient sound survey are presented as octave band statistical distribution and A-weighted histograms and statistical distributions in Appendix IV-A. Figures IV A-1 through IV A-16 contain the $L_{eq}$, $L_1$, $L_{10}$, $L_{50}$, $L_{90}$, $L_{95}$, and $L_{99}$ of the sound pressure levels at the octave band center frequencies. Each figure also contains an A-weighted sound level histogram, indicating the number of times a particular sound level occurred during the measurement period and the cumulative distribution of the A-weighted sound levels indicating the percentage of time a sound level is exceeded. Table IV-22, which summarizes the results, also contains the computed $L_{dn}$ for each measurement location. The $L_{dn}$ was computed from the measured data by considering the measured data as representative of the period in which the measurements were made. The $L_{eq}$ value for each period is used together with the number of hours which this value represents to compute the $L_{dn}$. The equation which follows illustrates this computation. Nighttime sound levels are weighted by 10 decibels in accordance with the Environmental Protection Agency description of day-night sound level.

$$L_{dn} = 10 \log \left(\frac{1}{24}\left(5\text{x}10^{L_m/10} + 6\text{x}10^{L_a/10} + 4\text{x}10^{L_e/10} + 9\text{x}10^{(L_n+10)/10}\right)\right)$$

$L_m$ - morning; $L_a$ - afternoon; $L_e$ - evening

$L_n$ - nighttime

## 3.2 ENVIRONMENTAL IMPACTS

Impacts on noise levels resulting from the proposed action are described below. Impacts due to alternative actions are described in Section 3.5.4.2.

### 3.2.1 Noise Sources

### 3.2.1.1 Mining

Background ambient sound levels would be affected by the operation of mining and process plant equipment. Principal noise sources and the associated A-weighted sound levels that were used to compute the effect of noise on offsite noise-sensitive land uses are presented below (USEPA, 1979):

| Noise Source | A-Weighted Sound Level at 60m |
|---|---|
| Dragline | 61 dB |
| Front End Loader | 72 dB |
| Off Road Trucks | 76 dB |
| Water Flotation Facility | 72 dB |
| Dryer Facility | 70 dB |
| Land Clearing Operation | 74 dB |
| Reclamation Operation | 74 dB |

The noise prediction model used in this study considers the possibility that all of the above sources would operate in their noisiest mode simultaneously. The environment may have a considerable effect on the transmission of sound over long distances since sound is absorbed by the medium through which it passes, such as air, grass, shrubs and trees. Wind and temperature gradients also affect sound transmission by bending the sound waves, reinforcing (amplifying) or spreading (attenuating) them before they reach the receiver. However, these effects were not considered in this study.

The approach taken in the following analysis is conservative since only the hemispherical spreading of the sound energy is considered. Thus, the A-weighted sound level produced by the source (measured at 200 feet) is reduced in accordance with the following relationship:

$$L_A = L_S - 20 \log \left(\frac{d}{200}\right)$$

where: $L_A$ = the A-weighted sound level at the receiver,

$L_S$ = the A-weighted sound level 200 feet from the source, and

d = the distance from source to receiver in feet.

### 3.2.1.2 Offsite

The two principal offsite noise sources are road traffic and freight trains. Road traffic noise projections were made using U.S. Department of Transportation (1978) traffic noise models. Freight train noise would consist of the short-duration locomotive noise and the longer duration (depending upon the number of cars) wheel/rail interaction noise. Freight train noise level measurement data, shown on Figure IV-6, indicate that the noise emission of a locomotive traveling at 30 mph is about 93 dB measured at 50 feet while the wheel/rail noise is about 78 dB at 50 feet (Interstate Commerce Commission, 1980).

## 3.2.2 Sound Levels at the Mine Boundary

### 3.2.2.1 Equivalent Sound Levels

Noise impacts were assessed at the property boundaries and at the town of Ona. Sound emitted from the mining operations, the processing plant, local road traffic, and railroad were extrapolated to the property boundaries (baseline measurement Locations 2 through 4, Figure IV-3) and were compared with the pre-mining sound levels and noise impact criteria suggested by federal agencies. The sound transmission model is conservative as it only considers the hemispherical divergence of sound and no atmospheric or ground attenuation effects.

Mining

The proposed action involves a dragline feeding stock to a slurry pipeline. Since two mining operations would occur simultaneously, the draglines would be the principal noise source at two locations. The operation of the dragline would affect noise sensitive property areas only during those years when mining occurred nearby.

A typical dragline emits an A-weighted sound level at 200 feet of 61 dB. But the emissions at the maximum sound level occur only about 80 percent of the time, resulting in a usage factor of 0.8. Thus, the Equivalent Sound Level, $L_{eq}$, at 200 feet for the dragline operation is 60 dB.

Since mining cannot take place any closer than 500 feet to residential property boundaries, the property line equivalent sound level would reach 52 dB. At Location 1 at Ona, this level would occur sometime during years 1 through 4, 21 through 24, and 25 through 26. At Location 2, consisting of four residences and three trailer homes, this level would occur during years 9 through 12. At Location 4, which consists of the New Zion Church and one residence, this level would occur during years 17 through 20. At Location 3, which represents one residence, mining activities would be no closer than 2,000 feet during any phase of the project. The maximum $L_{eq}$ contributed by mining would be 40 dB during years 1 through 4.

For the first 10 to 15 years, construction of miscellaneous items such as tall dams would require dozers, compactors, and other types of construction equipment. These equipment items would be used principally on-site and not necessarily near property boundaries. The noise from these operations would be transient and of a short duration. Thus, no noise impact is anticipated.

### Process Plant

Principal noise sources of the process plant consist of a water flotation facility and rock dryer facility which would emit an A-weighted equivalent sound level of 74 dB as measured at 200 feet from the center of the plant area. Distances from the plant to the baseline sound level measurement locations are:

| | |
|---|---|
| Location 1 | 11,000 feet |
| Location 2 | 17,000 feet |
| Location 3 | 10,000 feet |
| Location 4 | 52,000 feet. |

### 3.2.2.2 Day-Night Sound Levels

People residing in the town of Ona and residents along the mine boundary would be slightly affected by mining noise during the period of mining activity when the equipment operates as close as 500 feet to the property line. Residents living near both the property line and the railroad would experience noise from both sources during the period when mining is close by.

The table below presents a summary of the present ambient sound levels and mine-related future sound levels (without mitigation) during the appropriate period:

| Location | Baseline Day/Night Sound Level (dB) | Years of Mining Activity | Future Day/Night Sound Level (dB) |
|---|---|---|---|
| 1. Ona | 64.7 | 1-4<br>21-24<br>25-26 | 65.7 |
| 2. East Boundary | 53.3 | 9-12 | 60 |
| 3. Vandolah Road | 54.2 | 1-4 | 60 |
| 4. New Zion Church | 61.6 | 17-20 | 63.5 |

The day-night sound level ($L_{dn}$) is a term suggested by the USEPA (1974). Nighttime sound levels included in the $L_{dn}$ are penalized (increased) by 10 dB to account for the increased sensitivity of people to nighttime noise disturbance. The $L_{dn}$ is calculated from the following relationship:

$$L_{dn} = 10 \log \left(\frac{1}{24} \left(15 \times 10^{L_d/10} + 9 \times 10^{(L_n + 10)/10}\right)\right)$$

Therefore, for a mining activity operating 24 hours per day at 500 feet from the mine boundary, the generated day-night sound level would be:

$$L_{dn} = 10 \log \left(\frac{1}{24} \left(15 \times 10^{5.2} + 9 \times 10^{6.2}\right)\right)$$

$$= 58.4 \text{ dB}$$

Future day/night sound levels are computed by logarithmic addition of baseline daytime and nighttime and predicted daytime and nighttime sound levels, respectively, for the proposed activity.

The USEPA has identified an $L_{dn}$ of 55 dB as requisite for the protection of public health and safety (USEPA, 1974). However, since ambient sound levels exceed an $L_{dn}$ of 55 dB at most of the residential areas in the United States (including the town of Ona), the USEPA has designated an $L_{dn}$ of 65 dB as a near-term goal and an $L_{dn}$ of 55 dB as a long-term goal (USEPA, 1977). On this basis, even the maximum noise impacts at nearby residences due to mining would be within recommended USEPA goals.

### 3.3 MITIGATIVE MEASURES

As predicted, maximum day/night ($L_{dn}$) sound levels would be below the USEPA short-term goal of 65 dBA; no mitigative measures are considered necessary for the proposed action.

## TABLE IV-1

## TOTAL POPULATION IN THE STUDY REGION 1970, 1975, and 1979

| County | April 1970 | July 1975 | Percent Change 1970-1975 | July 1979 | Percent Change 1975-1979 | Compound Annual Growth Rate 1970-1979 (Percent) |
|---|---|---|---|---|---|---|
| Charlotte | 27,559 | 42,190 | 53 | 55,860 | 32 | 8.2 |
| DeSoto | 13,060 | 18,190 | 39 | 19,199 | 6 | 4.4 |
| Hardee | 14,889 | 18,511 | 24 | 18,430 | 0 | 2.4 |
| Hillsborough | 490,265 | 605,697 | 24 | 637,567 | 5 | 3.0 |
| Manatee | 97,115 | 123,506 | 27 | 143,238 | 16 | 4.4 |
| Polk | 227,222 | 275,973 | 21 | 297,014 | 8 | 3.0 |
| Sarasota | 120,413 | 163,172 | 36 | 194,433 | 19 | 5.5 |
| Seven-County Region | 990,523 | 1,247,139 | 26 | 1,365,741 | 10 | 3.6 |
| Florida | 6,791,418 | 8,485,230 | 25 | 9,294,250 | 10 | 3.6 |

Sources: U.S. Department of Commerce, 1972
University of Florida, 1979a.
University of Florida, 1979b.

## TABLE IV-2

## PROJECTED POPULATION IN THE STUDY REGION 1985, 1990, and 2000

| County | April 1985 | April 1990 | April 2000 | Compound Annual Growth Rate 1979-2000 (Percent) |
|---|---|---|---|---|
| Charlotte | 73,000 | 86,600 | 102,100 | 2.1 |
| DeSoto | 22,700 | 25,600 | 29,500 | 2.1 |
| Hardee | 19,900 | 21,400 | 23,900 | 1.2 |
| Hillsborough | 727,900 | 796,800 | 900,100 | 1.7 |
| Manatee | 168,200 | 189,400 | 217,400 | 2.0 |
| Polk | 336,100 | 368,300 | 416,300 | 1.6 |
| Sarasota | 236,700 | 271,400 | 314,500 | 2.3 |
| Seven-County Region | 1,584,500 | 1,759,500 | 2,003,800 | 1.8 |
| Florida | 10,810,800 | 11,978,100 | 13,624,100 | 1.8 |

Source: University of Florida, 1980.

## TABLE IV-3

## EMPLOYMENT CHARACTERISTICS IN THE STUDY REGION 1979 ANNUAL AVERAGE AND JULY 1980

| | Annual Average, 1979 | | | Unemployment Rate (Percent) | |
|---|---|---|---|---|---|
| County | Labor Force | Employment | Unemployment | 1979 | July 1980 |
| Charlotte | 16,646 | 15,955 | 691 | 4.2 | 5.5 |
| DeSoto | 6,234 | 5,826 | 408 | 6.5 | 10.4 |
| Hardee | 8,797 | 8,093 | 704 | 8.0 | 12.1 |
| Hillsborough | 285,091 | 271,005 | 14,086 | 4.9 | 6.5 |
| Manatee | 55,896 | 53,505 | 2,391 | 4.3 | 6.6 |
| Polk | 125,210 | 113,027 | 12,183 | 9.7 | 15.3 |
| Sarasota | 68,210 | 65,325 | 2,885 | 4.2 | 5.8 |
| Seven-County Region | 566,084 | 532,736 | 33,348 | 5.9 | 8.5 |
| Florida | 3,835,000 | 3,605,000 | 230,000 | 6.0 | 7.6 |

Source: Florida Department of Labor and Employment Security, March 1980 and August 1980.

## TABLE IV-4

## WAGE AND SALARY EMPLOYMENT BY INDUSTRY FOR THE STUDY REGION 1973 and 1978

| Study Area | 1973 | Percent of Total | 1978 | Percent of Total |
|---|---|---|---|---|
| Nonagricultural Wage and Salary Employment | 474,243 | 96 | 554,661 | 96 |
| Manufacturing | 61,289 | 12 | 69,620 | 12 |
| Construction | 39,185 | 8 | 41,366 | 7 |
| Transportation and Public Utilities | 27,265 | 6 | 30,306 | 5 |
| Trade | 114,639 | 23 | 130,398 | 23 |
| Finance, Insurance, and Real Estate | 25,186 | 5 | 30,661 | 5 |
| Services | 85,140 | 17 | 106,088 | 18 |
| Government | 75,486 | 15 | 88,459 | 15 |
| Non-farm Proprietors | 37,000 | 7 | 45,809 | 8 |
| Other[a] | 9,053 | 2 | 11,954 | 2 |
| Agricultural Employment | 19,753 | 4 | 20,906 | 4 |
| TOTAL | 493,996 | 100[b] | 575,567 | 100[b] |

---

[a] Includes mining, agricultural services, forestry, fisheries, and other.

[b] Rounding error incorporated.

Source: U.S. Department of Commerce, 1980a. Percentages calculated.

## TABLE IV-5

## LEADING EMPLOYMENT SECTORS IN THE STUDY REGION[a]

Page 1 of 2

| 1973 | | 1978 | |
|---|---|---|---|
| Sector | Percent of Total Employment | Sector | Percent of Total Employment |
| **CHARLOTTE** | | | |
| (10,897) | | (14,588) | |
| Trade | 22 | Services | 27 |
| Services | 20 | Trade | 20 |
| Finance, Insurance, Real Estate | 17 | Non-farm Proprietors | 12 |
| Non-farm Proprietors | 12 | Construction | 11 |
| Government | 10 | Finance, Insurance, Real Estate | 11 |
| **DESOTO** | | | |
| (6,627) | | (8,277) | |
| Government | 38 | Government | 36 |
| Agriculture | 24 | Agriculture | 22 |
| Trade | 12 | Trade | 12 |
| Manufacturing | 6 | Other | 10 |
| Non-farm Proprietors | 6 | Services | 6 |
| **HARDEE** | | | |
| (5,987) | | (7,205) | |
| Agriculture | 33 | Agriculture | 29 |
| Trade | 14 | Government | 15 |
| Services | 14 | Other | 14 |
| Government | 14 | Trade | 14 |
| Non-farm Proprietors | 9 | Services | 8 |
| | | Non-farm Proprietors | 8 |
| **HILLSBOROUGH** | | | |
| (261,323) | | (289,520) | |
| Trade | 25 | Trade | 25 |
| Services | 17 | Services | 19 |
| Government | 17 | Government | 17 |
| Manufacturing | 13 | Manufacturing | 13 |
| Construction | 8 | Construction | 8 |

TABLE IV-5 (Continued) Page 2 of 2

| 1973 | | 1978 | |
|---|---|---|---|
| Sector | Percent of Total Employment | Sector | Percent of Total Employment |
| | MANATEE | | |
| (37,796) | | (48,491) | |
| Trade | 22 | Trade | 23 |
| Government | 16 | Services | 17 |
| Services | 15 | Government | 16 |
| Manufacturing | 15 | Manufacturing | 13 |
| Non-farm Proprietors | 10 | Other | 11 |
| | POLK | | |
| (109,640) | | (132,039) | |
| Trade | 21 | Trade | 19 |
| Services | 16 | Services | 16 |
| Manufacturing | 16 | Manufacturing | 15 |
| Government | 13 | Government | 13 |
| Construction | 7 | Non-farm Proprietors | 13 |
| Non-farm Proprietors | 7 | | |
| | SARASOTA | | |
| (61,726) | | (75,447) | |
| Trade | 23 | Services | 26 |
| Services | 23 | Trade | 25 |
| Non-farm Proprietors | 12 | Other | 13 |
| Construction | 12 | Government | 11 |
| Government | 12 | Construction | 9 |
| | SEVEN-COUNTY REGION | | |
| (493,996) | | (575,567) | |
| Trade | 23 | Trade | 23 |
| Services | 17 | Services | 18 |
| Government | 15 | Government | 15 |
| Manufacturing | 12 | Manufacturing | 12 |
| Other | 9 | Other | 10 |

Source: U.S. Department of Commerce, 1980a.

[a] Population levels provided in parentheses.

[b] "Other" employment consists of mining, agricultural services, forestry, fisheries, and other.

## TABLE IV-6

## COUNTY OF RESIDENCE FOR MINING AND CHEMICAL WORKERS
## DECEMBER 1979

| County | Mining Employment | Chemical Employment | Total |
|---|---|---|---|
| Charlotte | 0 | 0 | 0 |
| DeSoto | 1 | 0 | 1 |
| Hardee | 312 | 52 | 364 |
| Hillsborough | 1,196 | 2,270 | 3,466 |
| Manatee | 4 | 109 | 113 |
| Polk | 4,005 | 2,674 | 6,679 |
| Sarasota | 0 | 4 | 4 |
| TOTAL | 5,518 | 5,109 | 10,627 |

Source: Tubbs, 1980.

TABLE IV-7

TOTAL PERSONAL INCOME AND PER CAPITA INCOME IN THE STUDY REGION
1969, 1978

| | Total Personal Income | | Per Capita Personal Income | | | | |
|---|---|---|---|---|---|---|---|
| | Millions of Dollars | | Dollars | | Percent of U.S. Average | | Geometric Rate of Change[a] |
| County | 1969 | 1978 | 1969 | 1978 | 1969 | 1978 | 1969-1978 |
| Charlotte | 76 | 332 | 2,879 | 7,099 | 79 | 91 | 0.105 |
| DeSoto | 33 | 110 | 2,554 | 6,514 | 70 | 83 | 0.109 |
| Hardee | 43 | 117 | 2,908 | 6,898 | 79 | 88 | 0.100 |
| Hillsborough | 1,499 | 4,064 | 3,099 | 6,955 | 85 | 89 | 0.093 |
| Manatee | 290 | 945 | 3,081 | 7,315 | 84 | 93 | 0.100 |
| Polk | 693 | 1,960 | 3,053 | 7,045 | 83 | 90 | 0.097 |
| Sarasota | 492 | 1,624 | 4,277 | 9,310 | 117 | 119 | 0.090 |
| Florida | 22,824 | 65,130 | 3,437 | 7,578 | 94 | 97 | 0.092 |

---

[a] The geometric rate of change in per capita personal income for the U.S. was 0.088 from 1969 to 1978.

Source: U.S. Department of Commerce, 1980b.

## TABLE IV-8

## FARM AND TOTAL INCOME IN THE STUDY REGION, 1978
(In thousands of dollars)

| County | Farm Income | Total | Farm Income As Percentage of Total |
|---|---|---|---|
| Charlotte | 3,438 | 332,241 | 1 |
| DeSoto | 19,119 | 110,193 | 17 |
| Hardee | 37,023 | 117,244 | 32 |
| Hillsborough | 71,265 | 4,063,723 | 2 |
| Manatee | 41,402 | 945,152 | 4 |
| Polk | 140,566 | 1,960,093 | 7 |
| Sarasota | 4,975 | 1,624,004 | <1 |
| Seven-County Area | 317,788 | 9,152,650 | 3 |

---

Source: U. S. Department of Commerce, 1980c.

### TABLE IV-9

### LOCATION QUOTIENTS (LQ) OF MAJOR INDUSTRIAL SECTORS IN THE STUDY REGION AND HARDEE COUNTY, 1978

| Industrial Sectors | Percent Employment Study Region | Percent Employment Hardee County | Percent Employment U.S. | LQ Study Region | LQ Hardee County |
|---|---|---|---|---|---|
| Agriculture | 4 | 29 | 4 | 1.00 | 7.25 |
| Construction | 7 | 1 | 5 | 1.40 | 0.20 |
| Manufacturing | 12 | 5 | 22 | 0.55 | 0.23 |
| Transportation and Public Utilities | 5 | 3 | 5 | 1.20 | 0.60 |
| Wholesale & Retail Trade | 23 | 14 | 21 | 1.10 | 0.67 |
| Finance, Insurance, and Real Estate | 5 | 2 | 5 | 1.00 | 0.40 |
| Services | 18 | 8 | 17 | 1.06 | 0.47 |
| Government | 15 | 15 | 16 | 0.94 | 0.94 |
| Non-farm Proprietors | 8 | 8 | 4 | 2.00 | 2.00 |
| Other[a] | 2 | 15 | 1 | 2.00 | 15.00 |
| TOTAL | 100[b] | 100 | 100 | -- | -- |

---

Based on: Employment figures from U.S. Department of Commerce, 1980a,b.

[a] Other = Mining and agricultural services, forestry, fisheries, and "other."

[b] Rounding error incorporated.

## TABLE IV-10

## HOUSING SUPPLY, HARDEE COUNTY, 1970 AND ESTIMATED 1976, 1980

| Year | Occupied Units | Vacant Units | Total Housing Units | Percent Vacancy |
|---|---|---|---|---|
| 1970 | 4,368 | 329 | 4,697 | 7.0 |
| 1976 | 5,852 | 212 | 6,064 | 3.5 |
| 1980 | 6,319 | 421 | 6,740 | 6.2 |

Source: Central Florida Regional Planning Council, 1978.

## TABLE IV-11

## DEFINITIONS OF TRAFFIC LEVEL OF SERVICE

| Level of Service | Descriptions |
|---|---|
| A | A condition of free flow, accompanied by low volumes and high speeds. |
| B | A condition of stable flow, with operating speeds beginning to be restricted somewhat by traffic conditions. |
| C | Still a condition of stable flow, but speeds and maneuverability are more closely controlled by the higher volumes. |
| D | Approaching unstable flow, with tolerable operating speeds being maintained, though considerably affected by changes in operating conditions. |
| E | A condition of unstable flow, with possible stoppages of momentary duration and lower operating speeds typically in the neighborhood of 30 miles per hour. |
| F | A condition where speeds are reduced substantially, and stoppages may occur for short or long periods of time because of downstream congestion. |

Source: Pignataro, 1973.

TABLE IV-12

ANNUAL PEAK CONSTRUCTION AND OPERATION PHASE IMPACTS ON POPULATION, EMPLOYMENT, AND PERSONAL INCOME

| | Annual Projected Impacts | | Annual Study Region Impacts | | | | Annual Hardee County Impacts | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | Construction[a] | Operation | Construction[a] | | Operation | | Construction[a] | | Operation | |
| | Total | Total | Total | Percent Change | Total | Percent Change | Total | Percent Change | Total | Percent Change |
| Population[b] | 200 | 130 | 200 | <0.01 | 130 | <0.01 | 20 | 0.1 | 15 | 0.1 |
| Employment[c] | 700 | 450 | 630 | 0.1 | 410 | 0.1 | 70 | 0.8 | 45 | 0.5 |
| Personal Income ($x10^6$)[d] | $14.0 | $6.0 | $12.6 | 0.1 | $5.4 | <0.01 | $1.3 | 0.9 | $0.5 | 0.3 |

---

Based on: MCC, 1977.

[a] Estimated to last two years.

[b] 1985 population projections are shown on Table IV-2

[c] Study region employment in 1985 is estimated to range between 570,000 and 600,000, based on interacting estimations and assumptions about population growth rate, unemployment rate, and labor force participation. Hardee County employment in 1985 is estimated to be 8,290 based on a 4 percent growth rate in the labor force.

[d] Personal income during 1985 in the study region is estimated to be $21.5 billion, based on a 13 percent annual growth rate. For Hardee County, 1985 personal income is estimated to be $150 million, based on a 12 percent annual growth rate.

## TABLE IV-13

## ANNUAL CONSTRUCTION AND OPERATING EXPENDITURES BY CATEGORY
(In millions of dollars)

| Category of Expenditure | Annual Projected Expenditures | | Annual Study Region Expenditures | | Annual Hardee County Expenditures | |
|---|---|---|---|---|---|---|
| | Construction[a] | Operation | Construction[a] | Operation | Construction[a] | Operation |
| Labor | 14.0 | 6.0 | 12.6 | 5.4 | 1.3 | 0.5 |
| Non-Labor | 33.5 | 21.0 | 30.1 | 18.9 | 3.0 | 1.9 |
| TOTAL | 47.5 | 27.0 | 42.7 | 24.3 | 4.3 | 2.4 |

---

[a] Construction is estimated to last 2 years.

Based on: MCC, 1977.

TABLE IV-14

PEAK CONSTRUCTION IMPACTS ON PROJECTED 1985 TRAFFIC FLOWS

| Road | Estimated Peak Hour Traffic Without Project (VPH)[a] 1985[b] | Number of Vehicles Added[c] | Estimated Peak Hour Traffic With Project (VPH) 1985[a] | Percent Increase | Estimated Capacity (VPH) 1985[b,d] |
|---|---|---|---|---|---|
| SR 62 | 300 | 350 | 650 | 117 | 900 |
| US 17 | 1835 | 245 | 2080 | 13 | 1800 |
| SR 64 (west of site) | 357 | 105 | 462 | 29 | 900 |
| SR 64 (east of site) | 463 | 70 | 533 | 15 | 900 |
| TOTAL | 2955 | 770 | 3725 | | |

[a] VPH - Vehicles per hour.

[b] Estimated from data supplied by Florida Department of Transportation, Office of Transportation Priorities. Assumes peak hour traffic is 15 percent of average daily traffic.

[c] Estimated from information contained in MCC (1977).

[d] Estimated with assistance from Smith (1980).

## TABLE IV-15

## GENERALIZED LAND USE, HARDEE COUNTY, 1975

| | Area | | Percent of County |
|---|---|---|---|
| | Hectares | Acres | |
| Urban or Built Up | 1,862 | 4,600 | 1.14 |
| Residential | 1,419 | 3,507 | 0.87 |
| Commercial and Services | 119 | 293 | 0.07 |
| Industrial | 67 | 166 | 0.04 |
| Transportation, Communications, and Utilities | 229 | 566 | 0.14 |
| Industrial and Commercial Complexes | -- | -- | -- |
| Mixed Urban or Built-up Areas | -- | -- | -- |
| Other Urban or Built-up Areas | 28 | 68 | 0.02 |
| Agricultural Land | 69,645 | 172,091 | 42.68 |
| Cropland and Pasture | 41,672 | 102,971 | 25.54 |
| Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas | 27,973 | 69,120 | 17.14 |
| Other Agricultural Land | -- | -- | -- |
| Rangeland | 58,569 | 144,723 | 35.89 |
| Forest Land | 4,573 | 11,299 | 2.80 |
| Water | 384 | 948 | 0.24 |
| Wetland | 28,091 | 69,412 | 17.22 |
| Barren Land | | | |
| Strip Mines, Quarries, and Gravel Pits | -- | -- | -- |
| Other Barren Land | 52 | 128 | 0.03 |
| County Total | 163,176 | 403,201 | 100.00 |

Source: Texas Instruments, Inc., 1978.

## TABLE IV-16

## GENERALIZED LAND USE, HARDEE COUNTY
## 1975 - 2035

| Applicable LUDA Level I/Level II | 1975 Percent of County | 1985 Percent of County | 2000 | | 2000 Percent of County | 2035 Percent of County | Percent Change: 1975 - 2000 |
|---|---|---|---|---|---|---|---|
| | | | Hectares | Acres | | | |
| Urban or Built Up | 1.14 | 1.7 | 3,383 | 8,359 | 2.06 | 2.97 | 81.7 |
| Residential | 0.87 | 1.04 | 2,375 | 5,869 | 1.46 | 2.45 | 67.8 |
| Commercial and Services | 0.07 | 0.10 | 192 | 474 | 0.12 | 0.16 | 71.4 |
| Industrial | 0.04 | 0.40 | 526 | 1,299 | 0.32 | 0.13 | 700.0 |
| Transportation, Communications, and Utilities | 0.14 | 0.14 | 229 | 566 | 0.14 | 0.14 | 0 |
| Industrial and Commercial Complexes | -- | -- | -- | -- | -- | -- | -- |
| Mixed Urban or Built-up Areas | -- | -- | -- | -- | -- | -- | -- |
| Other Urban or Built-up Areas | 0.02 | 0.02 | 61 | 151 | 0.04 | 0.09 | 100.0 |
| Agricultural Land | 42.68 | 40.34 | 68,427 | 169,079 | 41.93 | 40.99 | -1.8 |
| Cropland and Pasture | 25.54 | 25.31 | 41,139 | 101,652 | 25.21 | 24.99 | -1.3 |
| Orchards and Groves | 17.14 | 17.03 | 27,288 | 67,427 | 16.72 | 16.00 | -2.5 |
| Other Agricultural Land | -- | -- | -- | -- | -- | -- | -- |
| Rangeland | 35.89 | 35.68 | 58,267 | 143,976 | 35.71 | 35.76 | -0.5 |
| Forest Land | 2.80 | 2.80 | 4,573 | 11,300 | 2.80 | 2.80 | -- |
| Water | 0.24 | 0.23 | 383 | 947 | 0.23 | 0.23 | -4.3 |
| Wetland | 17.22 | 17.22 | 28,091 | 69,412 | 17.22 | 17.22 | 0 |
| Barren Land[a] | | | | | | | |
| Strip Mines, Quarries, and Gravel Pits | -- | -- | -- | -- | -- | -- | -- |
| Other Barren Land | 0.03 | 0.03 | 52 | 128 | 0.03 | 0.03 | 0 |
| County Total | 100.00 | 100.00 | 163,176 | 403,201 | 100.00 | 100.00 | 0 |

---

[a] No data currently available on land being mined for phosphate rock. See Section 2.1 and Figure IV-3 for phosphate land holdings.

Source: USEPA, 1978.

## TABLE IV-17

## MCC CATTLE PRODUCTIVITY

| Type | Acres | Acres Needed Per Head[a] | Total Cattle Supportable |
|---|---|---|---|
| Cattle Production | | | 1207-1505 |
| Pine flatlands range | 5,040 | 15-25 | 202-336 |
| Wet prairie range | 2,490 | 10-20 | 125-249 |
| Hammock range | 800 | 10-20 | 40-80 |
| Improved pasture | 5,040 | 6 | 840 |

---

[a] Based on acreage needed for one cow for one year.

Source: U.S. Soil Conservation Service, 1958.

## TABLE IV-18

## ESTIMATED ANNUAL CROP AND LIVESTOCK LOSSES DUE TO PROJECT

| | Maximum Annual Loss | | | | |
|---|---|---|---|---|---|
| | Oranges[a] | | Cattle[b] | | |
| Site Land Out of Production | No. Boxes | $ Value | No. Head | $ Value (x $10^3$) | Annual Loss ($ Value x $10^3$) |
| 100% | 8,400 | 55,000 | 1,200-1,500 | 600-750 | 655-805 |
| 25% | 8,400 | 55,000 | 300-375 | 150-188 | 205-243 |
| 10% | 8,400 | 55,000 | 120-150 | 60-75 | 115-130 |

---

[a] Based on a value of $6.50 per box.

[b] Based on a value of $500 per head.

## TABLE IV-19

## DATA ACQUISITION INSTRUMENTATION

| Type | Description | Serial Number |
|---|---|---|
| GR1933 | Precision Sound Level Meter[a] | 3383 |
| GR1961-9601 | 1" Electret Microphone[b] | 4020 |
| GR1561-A | Sound Level Calibrator[c] | 11640 |
| Nagra 4.2L | Tape Recorder | L101934 |
| Scotch 177-1/4-900 | Low Noise Magnetic Tape | N/A |

---

[a] Per ANS S1.4-1971.

[b] Microphone is omnidirectional, oriented vertically. Cable length 20 meters (60 ft). Cable recommended and supplied by manufacturer. Observer in car approximately 20 meters from microphone.

[c] Maintained and calibrated November 8, 1978.

## TABLE IV-20

## DATA ANALYSIS INSTRUMENTATION

| Type | Description | Serial Number |
|---|---|---|
| Nagra 4.2L | Tape Recorder | L101894 |
| GR1921-9076 | Real-Time Analyzer[a] | 2907 |
| DEC PDP8/e | Digital Computer | |

---

[a] Per ANS S1.11-1966

## TABLE IV-21

## METEOROLOGICAL CONDITIONS DURING MEASUREMENT PERIODS

| | Morning | Afternoon | Evening | Nighttime |
|---|---|---|---|---|
| **Location 1** | | | | |
| Date | 7/9/80 | 7/8/80 | 7/9/80 | 7/8/80 |
| Time | 1000 | 1430 | 1820 | 0000 |
| Temp (°C) | 29 | 34 | 32 | 26 |
| % Humidity | 81 | 60 | 71 | 94 |
| Wind Speed (m/s) | .9 | 0 | .9 | 0 |
| Wind Direction | N | -- | -- | -- |
| **Location 2** | | | | |
| Date | 7/8/80 | 7/8/80 | 7/9/80 | 7/8/80 |
| Time | 1120 | 1700 | 2000 | 2245 |
| Temp (°C) | 32 | 33 | 30 | 24 |
| % Humidity | 70 | 60 | 57 | 98 |
| Wind Speed (m/s) | .9 | .9 | Calm | 0 |
| Wind Direction | E | E | -- | -- |
| **Location 3** | | | | |
| Date | 7/8/80 | 7/8/80 | 7/9/80 | 7/8/80 |
| Time | 1000 | 1610 | 2040 | 2345 |
| Temp (°C) | 32 | 31 | 28 | 24 |
| % Humidity | 70 | 69 | 75 | 98 |
| Wind Speed (m/s) | 0 | 1.9 | .9 | Calm |
| Wind Direction | -- | N | -- | -- |
| **Location 4** | | | | |
| Date | 7/9/80 | 7/8/80 | 7/9/80 | 7/7/80 |
| Time | 1100 | 1430 | 1900 | 2230 |
| Temp (°C) | 30 | 32 | 30 | 26 |
| % Humidity | 69 | 65 | 54 | 94 |
| Wind Speed (m/s) | 1.8 | Breeze | 1.8 | Breeze |
| Wind Directon | -- | E | -- | E |

## TABLE IV-22

## SUMMARY OF ENVIRONMENTAL SOUND LEVELS

**Location 1** (Ona)

| Statistical Sound Level, dB | | Morning | Afternoon | Evening | Nighttime |
|---|---|---|---|---|---|
| | Date: | 7/9/80 | 7/8/80 | 7/9/80 | 7/8/80 |
| | Time: | 1000 | 1430 | 1820 | 0000 |
| $L_{10}$ | | 59 | 68 | 58 | 50 |
| $L_{50}$ | | 49 | 49 | 46 | 49 |
| $L_{90}$ | | 43 | 43 | 42 | 48 |
| $L_{eq}$ | | 59.9 | 64.6 | 56.8 | 53.5 |

$L_d$ = 62.1 dB
$L_n$ = 53.5 dB
$L_{dn}$ = 64.7 dB

**Location 2** (East Property Boundary)

| Statistical Sound Level, dB | | Morning | Afternoon | Evening | Nighttime |
|---|---|---|---|---|---|
| | Date: | 7/8/80 | 7/8/80 | 7/9/80 | 7/8/80 |
| | Time: | 1120 | 1700 | 2000 | 2245 |
| $L_{10}$ | | 32 | 44 | 40 | 49 |
| $L_{50}$ | | 30 | 41 | 37 | 47 |
| $L_{90}$ | | 30 | 39 | 35 | 46 |
| $L_{eq}$ | | 32.3 | 41.9 | 38.8 | 47.4 |

$L_d$ = 39.4 dB
$L_n$ = 47.4 dB
$L_{dn}$ = 53.3 dB

**Location 3** (Vandolah Road)

| Statistical Sound Level, dB | | Morning | Afternoon | Evening | Nighttime |
|---|---|---|---|---|---|
| | Date: | 7/8/80 | 7/8/80 | 7/9/80 | 7/8/80 |
| | Time: | 1000 | 1610 | 2040 | 2345 |
| $L_{10}$ | | 46 | 49 | 48 | 48 |
| $L_{50}$ | | 38 | 43 | 42 | 47 |
| $L_{90}$ | | 36 | 42 | 41 | 47 |
| $L_{eq}$ | | 50.5 | 49 | 47.2 | 47.5 |

$L_d$ = 49.2 dB
$L_n$ = 47.5 dB
$L_{dn}$ = 54.2 dB

**Location 4** (Church)

| Statistical Sound Level, dB | | Morning | Afternoon | Evening | Nighttime |
|---|---|---|---|---|---|
| | Date: | 7/9/80 | 7/8/80 | 7/9/80 | 7/7/80 |
| | Time: | 1100 | 1430 | 1900 | 2230 |
| $L_{10}$ | | 45 | 42 | 53 | 56 |
| $L_{50}$ | | 38 | 37 | 53 | 56 |
| $L_{90}$ | | 36 | 36 | 51 | 55 |
| $L_{eq}$ | | 42.7 | 43.6 | 52.9 | 55.7 |

$L_d$ = 48.3 dB
$L_n$ = 55.7 dB
$L_{dn}$ = 61.6 dB

Reproduced from
best available copy.

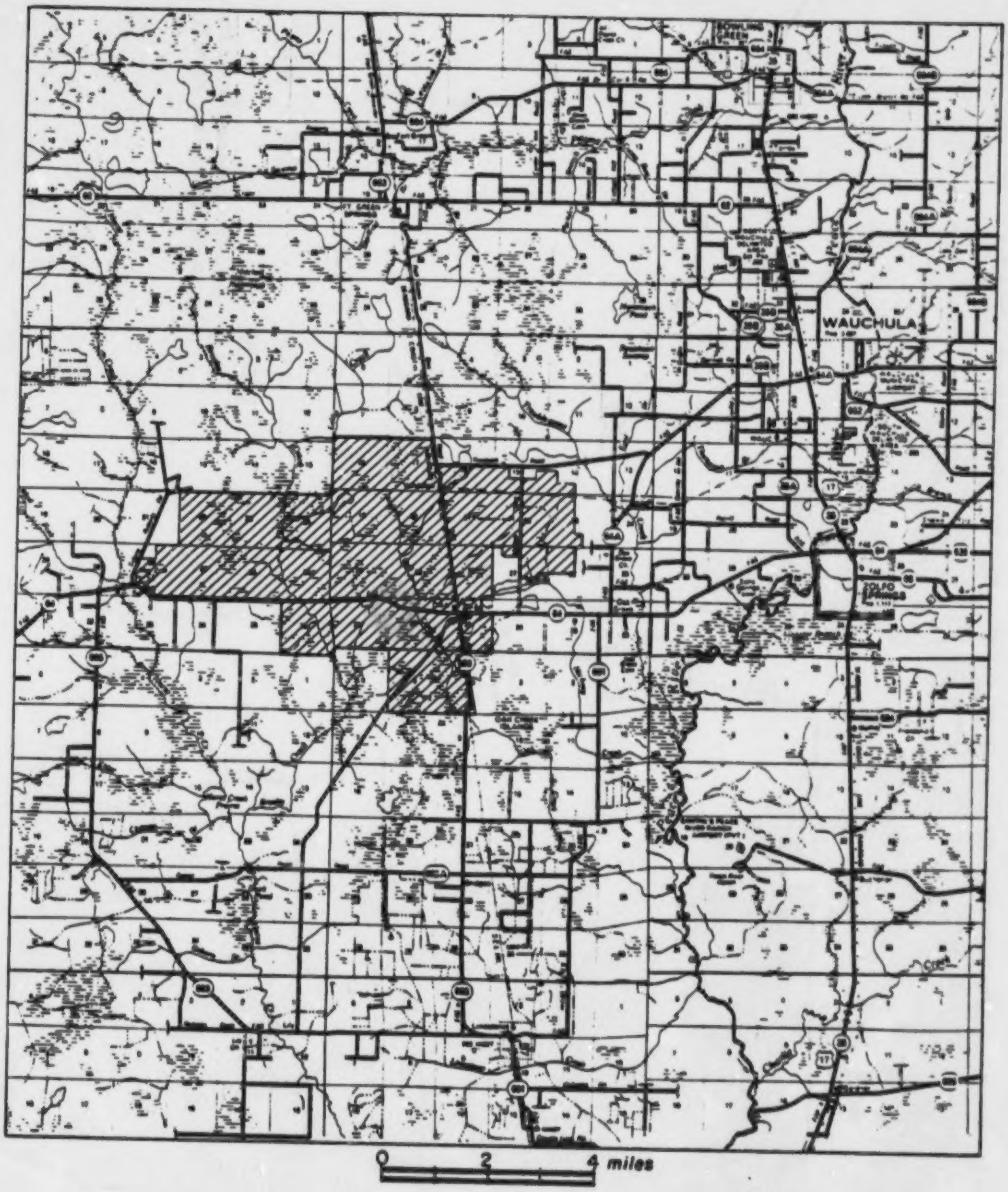
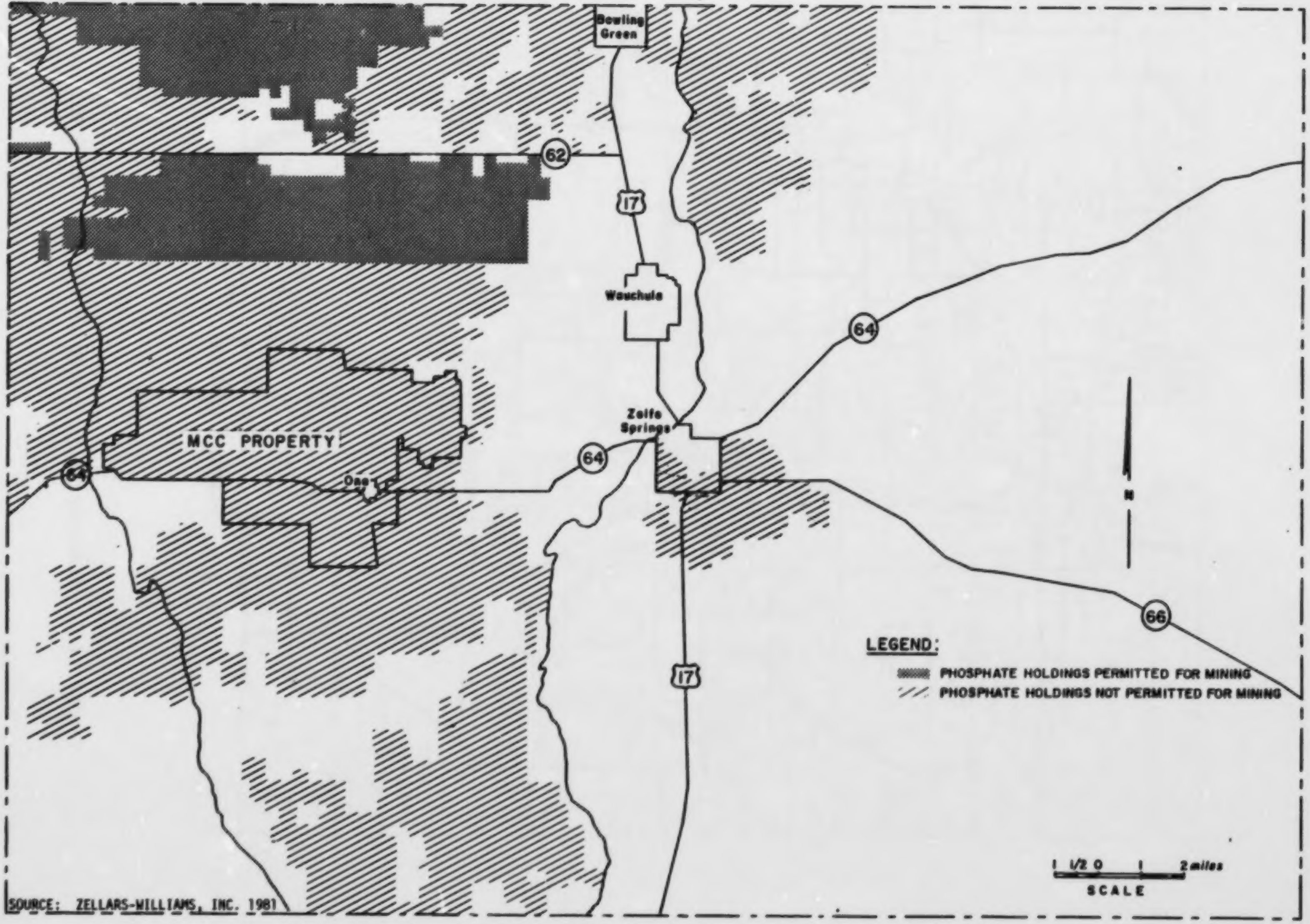

WAUCHULA
0
2
4 miles

Figure IV-1. Transportation System in the MCC Site Area.


Bowling Green
62
17
Wauchula
64
Zolfo Springs
MCC PROPERTY
Ona
64
N
66
17
LEGEND:
PHOSPHATE HOLDINGS PERMITTED FOR MINING
PHOSPHATE HOLDINGS NOT PERMITTED FOR MINING
1 1/2 0 1 2 miles
SCALE

SOURCE: ZELLARS-WILLIAMS, INC. 1981

Figure IV-2. Phosphate Industry Land Holdings in Hardee County.

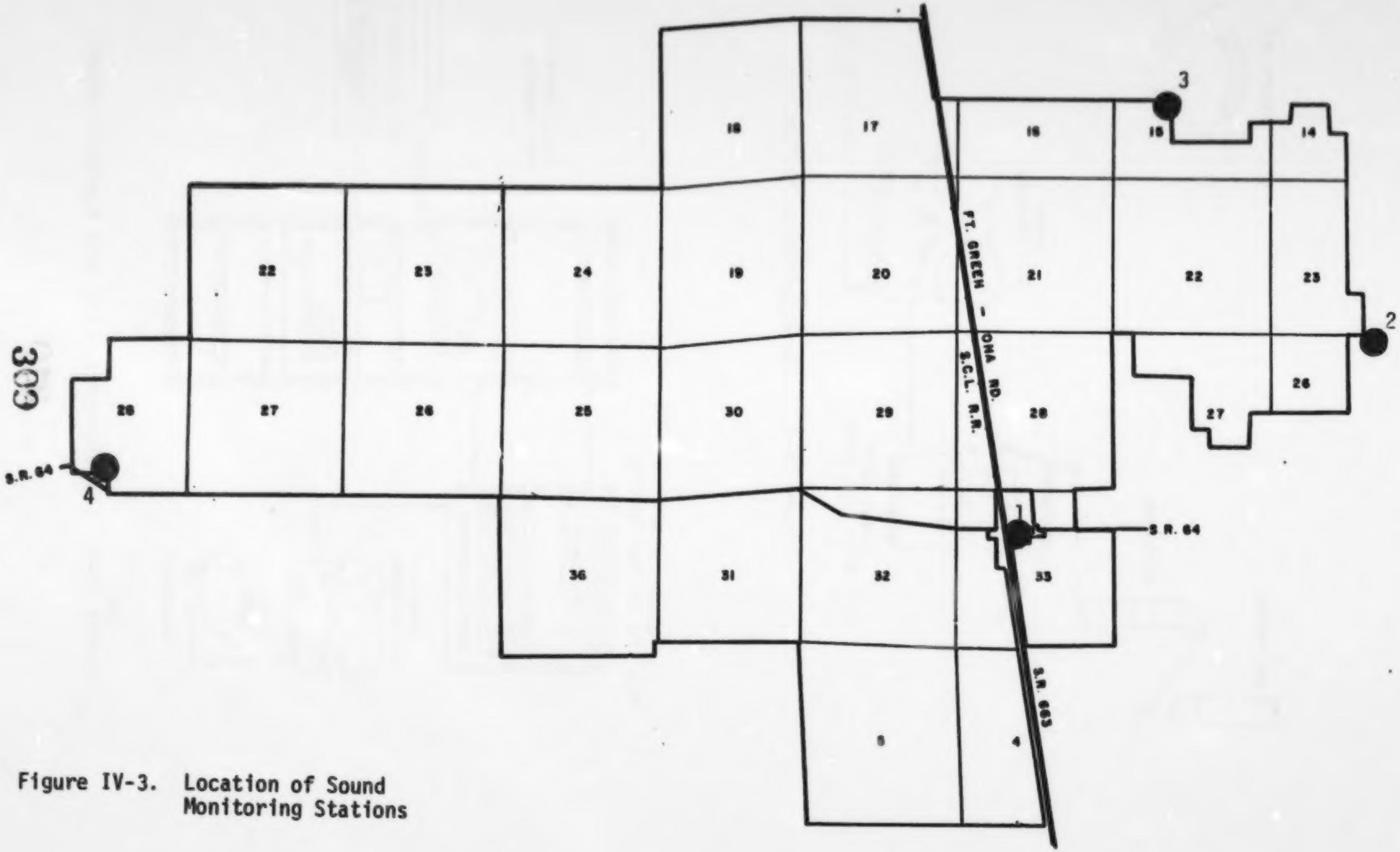

3
18
17
16
15
14
22
23
24
19
20
21
22
23
2
FT. GREEN – ONA RD.
S.C.L. R.R.
28
27
26
25
30
29
28
27
26
S.R. 64
4
1
S R. 64
36
31
32
33
S.R. 663
5
4

Figure IV-3. Location of Sound Monitoring Stations

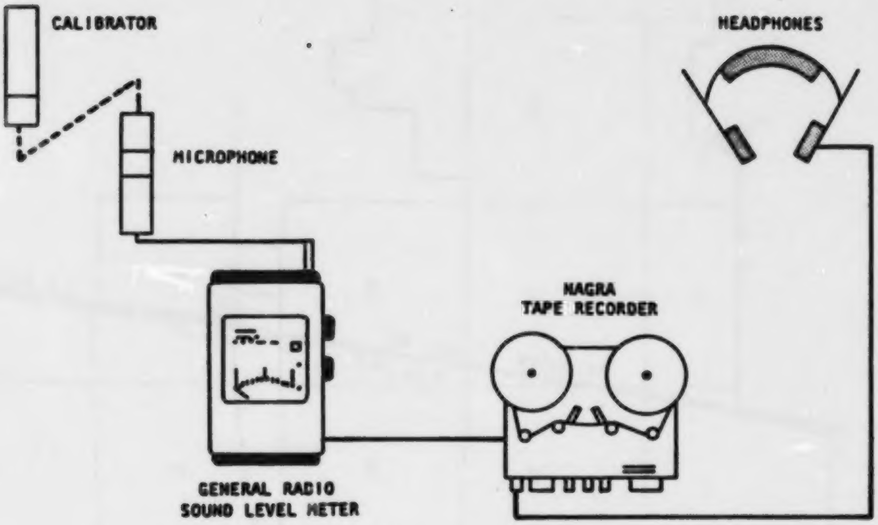

CALIBRATOR
MICROPHONE
HEADPHONES
NAGRA
TAPE RECORDER
GENERAL RADIO
SOUND LEVEL METER

Figure IV-4. Data Acquisition System.

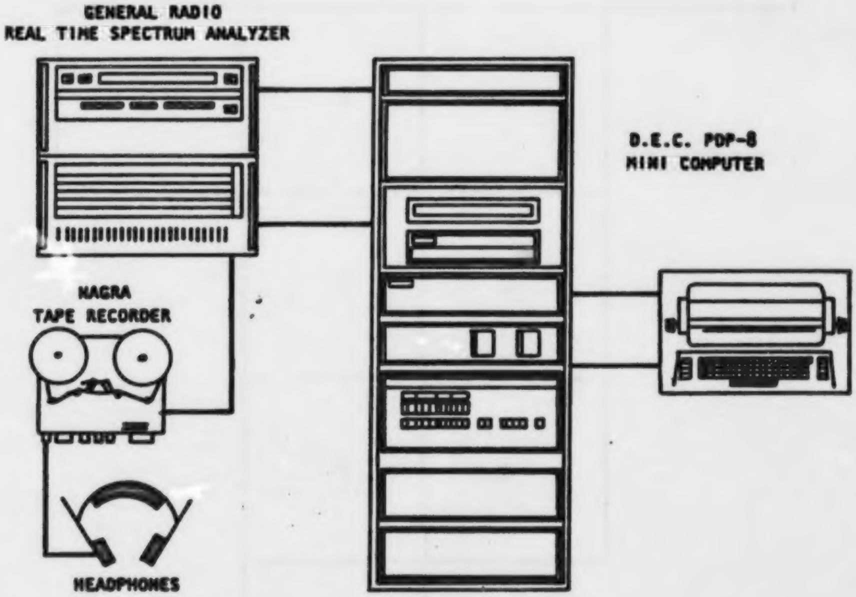
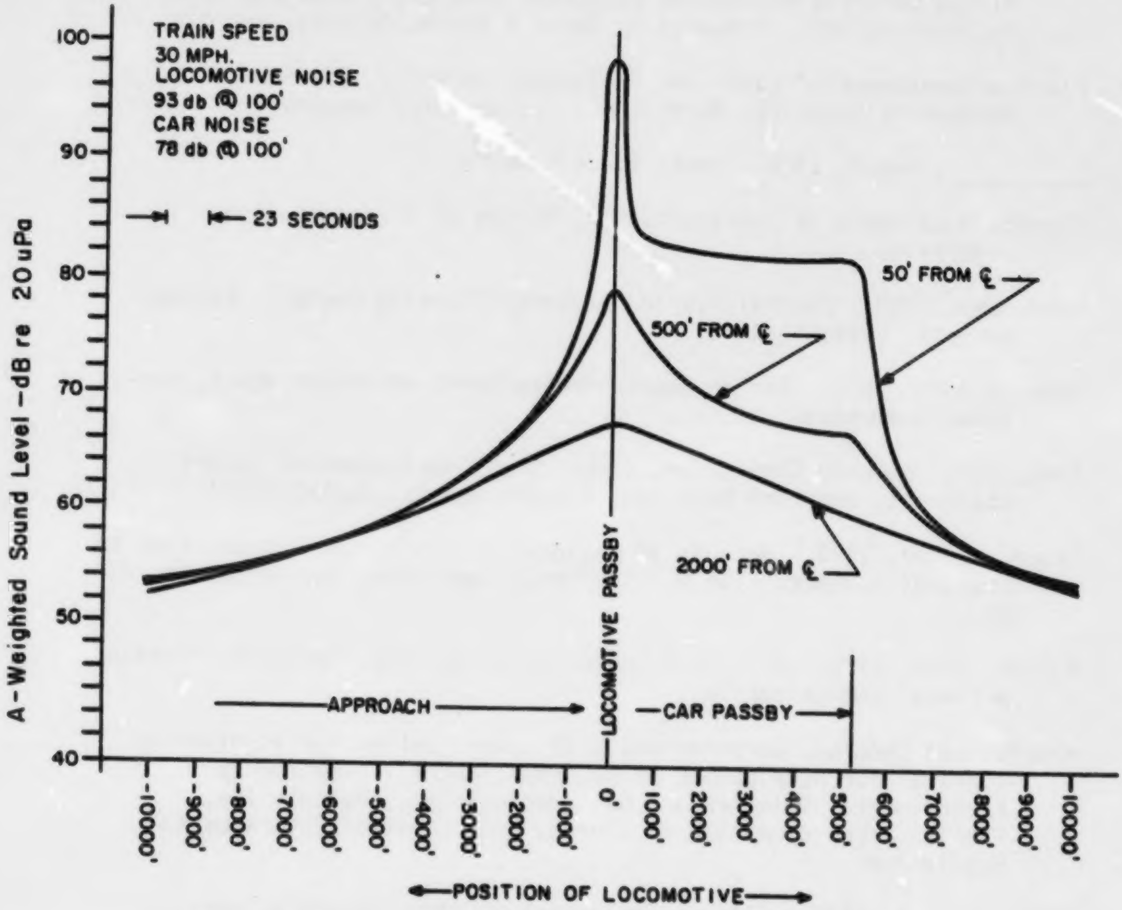

GENERAL RADIO
REAL TIME SPECTRUM ANALYZER
D.E.C. PDP-8
MINI COMPUTER
NAGRA
TAPE RECORDER
HEADPHONES

Figure IV-5. Computer Controlled Data Analysis System.



Source: Interstate Commerce Commission, 1980.

Figure IV-6. Typical 100 Car Unit Freight Train Sound Levels.

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## APPENDIX IV-A
## NOMENCLATURE

The range of sound pressures that can be heard by people varies from two-ten-thousand-millionths ($2 \times 10^{-10}$) of an atmosphere (sound barely audible to humans) to two-thousandths ($2 \times 10^{-3}$) of an atmosphere (sounds sufficiently loud to be painful). The decibel notation system is used to describe sound levels over this wide physical range. Essentially, the decibel unit compresses this range to a workable range using the following logarithmic relationship:

Sound level in decibels (dB) = $20 \log_{10} \left(\frac{P}{P_o}\right)$ where:

$P_o$ is a reference sound pressure required for a minimum sensation of hearing, and

P is the sound pressure

Zero decibels is assigned to the sound level producing a minimum sensation of hearing and 140 decibels to the minimum sound level which is painful to humans. Thus, a range whose upper limit is about 10 million times its lower limit is expressed on a scale of zero to 140.

The human ear does not perceive sounds at low frequencies in the same manner as those at higher frequencies. Low frequency sounds do not seem as loud as those of equal intensity at higher frequencies. The A-weighting network is provided in sound analysis systems to simulate the human ear. A-weighted sound levels are expressed in units of decibels. These A-weighted sound levels are used to evaluate hearing damage risk (OSHA) or community annoyance impact. These values are also used in federal, state, and local noise ordinances.

Sound is variable over time. Consequently, a statistical analysis is necessary to describe the temporal distribution of sound and to compute single-number descriptors that characterize the time-varying sound. This report contains the following statistical A-weighted sound levels:

$L_x$ - This is the sound level exceeded X percent of the time during the measurement period. For example:

$L_{90}$ - This is the sound level exceeded 90 percent of the time during the measurement period and is often used to represent the "residual" sound level.

$L_{50}$ - This is the sound level exceeded 50 percent of the time during the measurement period and is used to represent the "median" sound level.

$L_{10}$ - This is the sound level exceeded 10 percent of the time during the measurement period and is often used to represent the "intrusive" sound level.

Cumulative Distribution - The sound level values, usually plotted, of $L_x$ from $L_1$ to $L_{100}$ for a measurement period.

$L_{eq}$ - This is the equivalent steady sound level that provides an equal amount of acoustic energy as the time-varying sound.

$L_d$ - Day sound level, $L_{eq}$, for the daytime period (0700-2200) only.

$L_n$ - Night sound level, $L_{eq}$, for the nighttime period (2200-0700) only.

$L_{dn}$ - Day-night sound level, defined as:

$$L_{dn} = 10 \log_{10} [(15 \times 10^{L_d/10} + 9 \times 10^{(L_n + 10)/10})/24]$$

Note: A 10 dB correction factor is added to the nighttime sound level.

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```
FILE MISS13.DA

OCTAVE BAND    LEQ       L         L         L         L         L         L
    HZ.         DB        1         10        50        90        95        99

   31.5        62.6      73        64        57        54        53        51
   63          69.9      80        67        61        60        60        60
   125         64.4      77        64        51        45        45        44
   250         58.5      72        58        46        44        44        44
   500         54.4      66        53        44        44        44        44
   1000        53.4      65        52        44        44        44        44
   2000        51        63        49        44        44        44        44
   4000        49.6      61        45        44        44        44        44
   8000        49.3      56        54        44        44        44        44
   A-WT.       59.9      72        59        49        43        43        42
```

A-Weighted Sound Level - dB re: 20μPa

```
      41   *  0.1 %
      42   ******************  4.6 %
      43   ************************************************  12 %
      44   **************************************  9.6 %
      45   **************************  6.6 %
      46   **************************  6.5 %
      47   ******************  4.4 %
      48   *******************  4.8 %
      49   **************  3.5 %
      50   ***************  3.7 %
      51   **************  3.6 %
      52   ***************  3.8 %
      53   **************************  6.4 %
      54   *********************  5.2 %
      55   **********************  5.5 %
      56   ***************  3.7 %
      57   *******  1.8 %
      58   ************  3 %
      59   ******  1.5 %
      60   *****  1.2 %
      61   *******  1.7 %
      62   ****  0.9 %
      63   ***  0.7 %
      64   *****  1.4 %
      65   **  0.5 %
      66   **  0.4 %
      67   *  0.2 %
      68   **  0.4 %
      69   **  0.4 %
      70   **  0.4 %
      71   **  0.5 %
      72   *  0.2 %
      73   *  0.1 %
      74   *  0.2 %
      75   *  0.2 %
      76
      77   *  0.2 %
      78   *  0.1 %
      79
      80   *  0.1 %
      81
      82
      83   *  0.1 %

EQUIVALENT SOUND LEVEL =  59.9  DB

                  CUMULATIVE DISTRIBUTION

    (%) EXCEEDED                  SOUND PRESSURE LEVEL-DB
         95                                43
         90                                43
         85                                43
         80                                44
         75                                44
         70                                45
         65                                46
         60                                47
         55                                48
         50                                49
         45                                50
         40                                52
         35                                53
         30                                54
         25                                55
         20                                55
         15                                57
         10                                59
         5                                 62
```

FIGURE IV A-1
LOCATION 1
DATE 7/9/80
TIME 1000

```
FILE MISS06.DA

OCTAVE BAND    LEQ       L         L         L         L         L         L
   HZ.          DB        1        10        50        90        95        99

   31.5        67.1      80        69        55        52        51        50
   63          73.3      86        75        62        60        60        60
   125         70.9      83        73        56        46        45        44
   250         62.9      76        66        48        44        44        44
   500         58        71        60        44        44        44        44
   1000        58        69        61        44        44        44        44
   2000        56.6      69        59        44        44        44        44
   4000        52.7      63        54        44        44        44        44
   8000        48        58        50        44        44        44        44
   A-WT.       64.6      77        68        49        43        42        42


        42   ********************************  5.7 %
        43   **************************************************  8.9 %
        44   **************************  4.6 %
        45   ************************  4.2 %
        46   *******************************************  7.7 %
        47   *********************************************  8.1 %
        48   *****************************  5.2 %
        49   ***********************************  6.3 %
        50   *****************************  5.3 %
        51   ******************  3.3 %
        52   ******************  3.3 %
        53   ****************  2.9 %
        54   **************  2.5 %
        55   **********  1.7 %
        56   ***********  1.9 %
        57   ********  1.4 %
        58   ************  2.2 %
        59   **********  1.8 %
        60   *********  1.6 %
        61   ***********  2 %
        62   **********  1.7 %
        63   ********  1.4 %
        64   *******  1.3 %
        65   **************  2.5 %
        66   ****  0.6 %
        67   *******  1.3 %
        68   *******  1.3 %
        69   **********  1.8 %
        70   *********  1.5 %
        71   *******  1.2 %
        72   *****  0.9 %
        73   ***  0.5 %
        74   *******  1.3 %
        75   *  0.2 %
        76   ****  0.6 %
        77   ***  0.5 %
        78   *  0.1 %
        79   *  0.2 %
        80   *  0.1 %
        81   *  0.2 %
        82   *  0.2 %

EQUIVALENT SOUND LEVEL =  64.6  DB

              CUMULATIVE DISTRIBUTION

      (%) EXCEEDED           SOUND PRESSURE LEVEL-DB
          95                           42
          90                           43
          85                           44
          80                           45
          75                           46
          70                           46
          65                           47
          60                           48
          55                           49
          50                           49
          45                           50
          40                           52
          35                           53
          30                           56
          25                           58
          20                           61
          15                           64
          10                           68
          5                            71
```

A-Weighted Sound Level - dB re: 20µPa

FIGURE IV A-2
LOCATION 1
DATE  7/8/80
TIME  1430

```
FILE MISS15. DA

OCTAVE BAND   LEQ       L         L         L      . L         L         L
   HZ.         DB        1         10        50        90        95        99

   31. 5      57. 5      69        60        50        44        44        44
   63         64. 8      76        66        61        60        60        60
   125        62. 2      75        63        49        45        45        44
   250        57. 3      67        57        45        44        44        44
   500        52. 3      65        53        44        44        44        44
   1000       51. 1      63        52        44        44        44        44
   2000       48. 5      59        49        44        44        44        44
   4000       45. 5      52        44        44        44        44        44
   8000       44. 2      46        44        44        44        44        44
   A-WT.      56. 8      68        58        46        42        42        42
```

A-Weighted Sound Level - dB re: 20μPa

```
     41  **  0. 7 %
     42  **********************************************  15. 8 %
     43  *********************************  11. 5 %
     44  ***************************  9. 4 %
     45  *******************  6. 7 %
     46  ******************  6. 2 %
     47  ******************  6. 1 %
     48  ******************  6. 2 %
     49  *************  4. 6 %
     50  *********  3. 1 %
     51  *********  3. 2 %
     52  **********  3. 4 %
     53  **********  3. 6 %
     54  ******  1. 9 %
     55  ******  2. 1 %
     56  *****  1. 7 %
     57  ******  1. 9 %
     58  ******  2 %
     59  *****  1. 6 %
     60  ****  1. 3 %
     61  ****  1. 2 %
     62  ***  1. 1 %
     63  ***  1 %
     64  ***  0. 8 %
     65  ***  1 %
     66  *  0. 4 %
     67  *  0. 4 %
     68  *  0. 2 %
     69  *  0. 3 %
     70
     71  *  0. 1 %
     72  *  0. 2 %
     73  *  0. 2 %
     74
     75  *  0. 1 %
     76
     77
     78
     79
     80  *  0. 1 %
```

FIGURE IV A-3
LOCATION 1
DATE 7/9/80
TIME 1820

```
EQUIVALENT SOUND LEVEL =  56. 8  DB

           CUMULATIVE DISTRIBUTION

   (%) EXCEEDED            SOUND PRESSURE LEVEL-DB
        95                          42
        90                          42
        85                          42
        80                          43
        75                          43
        70                          44
        65                          44
        60                          45
        55                          46
        50                          46
        45                          47
        40                          48
        35                          49
        30                          50
        25                          52
        20                          53
        15                          56
        10                          58
        5                           62
```

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```
FILE MISS02.DA

OCTAVE BAND    LEQ       L         L         L         L         L         L
   HZ.          DB        1         10        50        90        95        99

   31.5        40.3      59        48        43        41        40        39
   63          53        61        53        51        50        50        50
   125         51.7      62        50        41        36        35        34
   250         50.1      60        40        35        34        34        34
   500         49.3      57        39        34        34        34        34
   1000        45.8      59        39        34        34        34        34
   2000        40.5      52        35        34        34        34        34
   4000        37.7      46        37        36        35        35        35
   8000        48.4      50        49        48        47        47        46
   A-WT.       53.5      63        50        49        48        48        47
```

A-Weighted Sound Level - dB re: 20µPa

```
 47  **  1.3 %
 48  ****************  15.6 %
 49  ***********************************************  46.6 %
 50  *****************************  28.1 %
 51  ****  3.2 %
 52  *  1 %
 53  *  0.6 %
 54  *  0.5 %
 55  *  0.6 %
 56  *  0.5 %
 57  *  0.1 %
 58  *  0.2 %
 59  *  0.2 %
 60  *  0.1 %
 61  *  0.2 %
 62
 63  *  0.3 %
 64  *  0.3 %
 65  *  0.2 %
 66  *  0.3 %
 67
 68
 69  *  0.1 %
 70
 71
 72
 73
 74
 75
 76  *  0.1 %
 77
 78  *  0.1 %
```

FIGURE IV A-4
LOCATION 1
DATE 7/8/80
TIME 0000

```
EQUIVALENT SOUND LEVEL =  53.5  DB

             CUMULATIVE DISTRIBUTION

    (%) EXCEEDED           SOUND PRESSURE LEVEL-DB
          95                         48
          90                         48
          85                         48
          80                         49
          75                         49
          70                         49
          65                         49
          60                         49
          55                         49
          50                         49
          45                         49
          40                         49
          35                         50
          30                         50
          25                         50
          20                         50
          15                         50
          10                         50
          5                          52
```

```
FILE MISS04.DA

OCTAVE BAND   LEQ      L       L       L       L       L       L
   HZ.         DB       1       10      50      90      95      99

  31.5        34.4     38      35      34      34      34      34
  63          50       51      50      50      50      50      50
  125         34.1     36      34      34      34      34      34
  250         34.1     35      34      34      34      34      34
  500         34       34      34      34      34      34      34
  1000        34       34      34      34      34      34      34
  2000        34       34      34      34      34      34      34
  4000        34       34      34      34      34      34      34
  8000        34       34      34      34      34      34      34
  A-WT.       32.3     37      32      30      30      30      30
```

A-Weighted Sound Level - dB re: 20µPa

```
 30  *****************************************************  83.2 %
 31  ****  5.1 %
 32  ****  6.3 %
 33  **  2.3 %
 34  *  1 %
 35  *  0.5 %
 36  *  0.3 %
 37  *  0.4 %
 38  *  0.2 %
 39
 40  *  0.1 %
 41  *  0.1 %
 42
 43  *  0.1 %
 44  *  0.1 %
 45
 46  *  0.1 %
 47
 48
 49  *  0.2 %
 50  *  0.1 %
 51
 52
 53
 54
 55  *  0.1 %

EQUIVALENT SOUND LEVEL =  32.3  DB

          CUMULATIVE DISTRIBUTION

  (%) EXCEEDED              SOUND PRESSURE LEVEL-DB
     95                              30
     90                              30
     85                              30
     80                              30
     75                              30
     70                              30
     65                              30
     60                              30
     55                              30
     50                              30
     45                              30
     40                              30
     35                              30
     30                              30
     25                              30
     20                              30
     15                              30
     10                              31
     5                               32
                                     33
```

FIGURE IV A-5
LOCATION 2
DATE 7/8/80
TIME 1120

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```
FILE MISS09.DA

OCTAVE BAND    LEQ        L         L         L         L         L         L
   HZ.          DB         1         10        50        90        95        99

   31.5        54.7       63        58        52        47        46        44
   63          54.7       63        56        53        51        51        51
   125         46.6       58        49        41        35        35        34
   250         38.1       49        40        35        34        34        34
   500         34.5       40        34        34        34        34        34
   1000        34         35        34        34        34        34        34
   2000        34.6       40        35        34        34        34        34
   4000        34.8       42        34        34        34        34        34
   8000        37.5       41        39        37        36        36        35
   A-WT.       41.9       49        44        41        39        39        39
```

A-Weighted Sound Level - dB re: 20µPa

```
38  *  0.6 %
39  ******************  10.6 %
40  ************************************************  27.9 %
41  ***********************************************  27.2 %
42  ****************************  16.1 %
43  ************  6.9 %
44  *******  4.3 %
45  ****  2.3 %
46  **  1.3 %
47  **  1.2 %
48  *  0.5 %
49  *  0.3 %
50  *  0.6 %
51  *  0.1 %
52
53  *  0.1 %
54  *  0.1 %

EQUIVALENT SOUND LEVEL =  41.9  DB

           CUMULATIVE DISTRIBUTION

   (%) EXCEEDED            SOUND PRESSURE LEVEL-DB
       95                            39
       90                            39
       85                            40
       80                            40
       75                            40
       70                            40
       65                            40
       60                            41
       55                            41
       50                            41
       45                            41
       40                            41
       35                            41
       30                            42
       25                            42
       20                            42
       15                            43
       10                            44
       5                             45
```

FIGURE IV A-6
LOCATION 2
DATE 7/8/80
TIME 1700

```
FILE MISS17.DA

OCTAVE BAND   LEQ       L        L        L        L        L        L
   HZ.         DB       1       10       50       90       95       99

   31.5       55.8     61       56       55       55       55       54
   63         51.3     58       52       51       50       50       50
   125        40.8     52       42       37       34       34       34
   250        34.5     38       35       34       34       34       34
   500        34.2     37       34       34       34       34       34
   1000       34.1     35       34       34       34       34       34
   2000       34.2     37       34       34       34       34       34
   4000       35.3     45       34       34       34       34       34
   8000       34.6     37       36       34       34       34       34
   A-WT.      38.8     48       40       37       35       34       34
```

A-Weighted Sound Level - dB re: 20μPa

```
 33  *  0.1 %
 34  ******************  5.4 %
 35  ***************************************************  16.6 %
 36  ******************************************************  17.8 %
 37  ************************************************  15.5 %
 38  *****************************************  13 %
 39  *******************************************  13.7 %
 40  *********************  7.5 %
 41  *********  3.3 %
 42  ******  1.9 %
 43  ****  1.3 %
 44  *  0.3 %
 45  *  0.3 %
 46  **  0.5 %
 47  **  0.7 %
 48  **  0.5 %
 49  *  0.2 %
 50
 51  *  0.4 %
 52
 53  *  0.1 %

EQUIVALENT SOUND LEVEL =  38.8  DB

          CUMULATIVE DISTRIBUTION

    (%) EXCEEDED           SOUND PRESSURE LEVEL-DB
       95                           34
       90                           35*
       85                           35
       80                           35
       75                           36
       70                           36
       65                           36
       60                           36
       55                           37
       50                           37
       45                           37
       40                           38
       35                           38
       30                           39
       25                           39
       20                           39
       15                           40
       10                           40
       5                            42
```

FIGURE IV A-7
LOCATION 2
DATE 7/9/80
TIME 2000

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```
FILE MISS11.DA

OCTAVE BAND   LEQ       L         L         L         L         L         L
   HZ.         DB        1         10        50        90        95        99

   31.5       48.9      54        53        45        44        44        43
   63         46.1      56        49        42        41        41        40
   125        46.5      58        51        35        34        34        33
   250        42.1      54        47        26        25        25        24
   500        33.5      45        36        27        26        25        25
   1000       29        37        30        28        27        27        27
   2000       28.3      30        29        28        28        27        27
   4000       34.2      36        35        34        33        33        33
   8000       46.2      49        48        46        45        45        45
   A-WT.      47.4      52        49        47        46        46        46
```

A-Weighted Sound Level - dB re: 20μPa

```
45  *  0.1 %
46  *****************************  29 %
47  ***************************************************  51.2 %
48  *******  6.8 %
49  *****  4.5 %
50  ****  4.4 %
51  ***  2.9 %
52  *  1 %
53  *  0.1 %

EQUIVALENT SOUND LEVEL =  47.4  DB

             CUMULATIVE DISTRIBUTION

    (%) EXCEEDED          SOUND PRESSURE LEVEL-DB
          95                          46
          90                          46
          85                          46
          80                          46
          75                          46
          70                          47
          65                          47
          60                          47
          55                          47
          50                          47
          45                          47
          40                          47
          35                          47
          30                          47
          25                          47
          20                          47
          15                          48
          10                          49
          5                           50
```

FIGURE IV A-8
LOCATION 2
DATE 7/8/80
TIME 2245

```
FILE MISS03.DA

OCTAVE BAND   LEQ      L        L        L        L        L        L
    HZ.       DB        1        10       50       90       95       99

   31.5       51.4     63       51       45       40       39       38
   63         60.8     68       57       51       50       50       49
   125        59.1     71       55       42       34       34       34
   250        49.6     61       42       34       34       34       34
   500        44.8     55       34       34       34       34       34
   1000       44.3     55       34       34       34       34       34
   2000       40.9     52       34       34       34       34       34
   4000       38       47       36       34       34       34       34
   8000       34.8     38       35       34       34       34       34
   A-WT.      50.5     62       46       38       36       36       36

        36  ********************  12.5 %
        37  ********************************************  28 %
        38  *******************************  19.7 %
        39  *********************  13.2 %
        40  ********  4.7 %
        41  *****  3.2 %
        42  ****  2.1 %
        43  ***  1.7 %
        44  ****  2 %
        45  ****  2.5 %
        46  **  1 %
        47  **  1.1 %
        48  ***  1.6 %
        49  *  0.6 %
        50  ***  1.4 %
        51  **  0.8 %
        52  *  0.5 %
        53  *  0.4 %
        54  *  0.3 %
        55  *  0.4 %
        56  *  0.1 %
        57  *  0.3 %
        58
        59  *  0.3 %
        60  *  0.2 %
        61  *  0.1 %
        62  *  0.4 %
        63  *  0.2 %
        64  *  0.1 %
        65  *  0.2 %
        66  *  0.1 %
        67
        68
        69
        70  *  0.1 %
        71
        72  *  0.1 %
        73
        74  *  0.2 %

EQUIVALENT SOUND LEVEL =  50.5  DB

            CUMULATIVE DISTRIBUTION

   (%) EXCEEDED            SOUND PRESSURE LEVEL-DB
       95                          36
       90                          36
       85                          37
       80                          37
       75                          37
       70                          37
       65                          37
       60                          37
       55                          38
       50                          38
       45                          38
       40                          38
       35                          39
       30                          39
       25                          40
       20                          41
       15                          43
       10                          46
       5                           50
```

A-Weighted Sound Level - dB re: 20µPa

FIGURE IV A-9
LOCATION 3
DATE 7/8/80
TIME 1000

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```
FILE MISS08.DA

OCTAVE BAND    LEQ        L          L          L          L          L          L
   HZ.          DB         1          10         50         90         95         99

   31.5       . 57.5       68         61         54         47         46         44
   63           60.9       64         62         61         60         60         60
   125          53         63         56         47         44         44         44
   250          48.6       59         50         44         44         44         44
   500          45.6       53         44         44         44         44         44
   1000         46.3       56         44         44         44         44         44
   2000         44.8       52         44         44         44         44         44
   4000         44.2       47         44         44         44         44         44
   8000         44         44         44         44         44         44         44
   A-WT.        49         60         49         43         42         42         41
```

A-Weighted Sound Level - dB re: 20µPa

```
41  ***  1.5 %
42  *********************************************  28.3 %
43  ***********************************  22.2 %
44  *************************  15.8 %
45  **************  8.7 %
46  *******  4.3 %
47  *******  4.2 %
48  ******  3.5 %
49  *****  2.6 %
50  ****  2.2 %
51  ***  1.5 %
52  **  1.2 %
53  *  0.5 %
54  **  0.9 %
55  *  0.5 %
56  *  0.6 %
57  *  0.3 %
58
59  *  0.2 %
60  *  0.3 %
61  *  0.1 %
62  *  0.1 %
63  *  0.1 %
64  *  0.1 %
65  *  0.2 %
66  *  0.2 %
67  *  0.1 %
68  *  0.1 %
69  *  0.1 %

EQUIVALENT SOUND LEVEL =  49  DB

           CUMULATIVE DISTRIBUTION

     (%) EXCEEDED          SOUND PRESSURE LEVEL-DB
        95                         42
        90                         42
        85                         42
        80                         42
        75                         42
        70                         43
        65                         43
        60                         43
        55                         43
        50                         43
        45                         44
        40                         44
        35                         44
        30                         45
        25                         45
        20                         46
        15                         48
        10                         49
        5                          52
```

FIGURE IV A-10
LOCATION 3
DATE 7/8/80
TIME 1610

```
FILE MISS18.DA

OCTAVE BAND   LEQ       L       L       L       L       L       L
  HZ.          DB        1       10      50      90      95      99

  31.5        59.7      73      61      53      48      46      45
  63          63.9      73      63      61      60      60      60
  125         57.7      70      56      46      44      44      44
  250         47.9      58      50      44      44      44      44
  500         44.5      50      44      44      44      44      44
  1000        44.6      51      44      44      44      44      44
  2000        44.1      46      44      44      44      44      44
  4000        44        44      44      44      44      44      44
  8000        44        44      44      44      44      44      44
  A-WT.       47.2      59      48      42      41      41      40
```

A-Weighted Sound Level - dB re: 20μPa

```
 40  **  1.1 %
 41  ******************************************************  32.7 %
 42  ***********************************  21.1 %
 43  ***********************  13.6 %
 44  *************  8 %
 45  *********  5.3 %
 46  *******  4.2 %
 47  ****  2.4 %
 48  ***  2 %
 49  **  1.1 %
 50  **  1.1 %
 51  ***  1.6 %
 52  **  1.3 %
 53  *  0.4 %
 54  *  0.7 %
 55  **  1.1 %
 56
 57  *  0.2 %
 58  **  0.9 %
 59  *  0.2 %
 60  *  0.4 %
 61
 62  *  0.2 %
 63
 64  *  0.2 %

EQUIVALENT SOUND LEVEL =  47.2  DB

          CUMULATIVE DISTRIBUTION

    (%) EXCEEDED              SOUND PRESSURE LEVEL-DB
       95                              41
       90                              41
       85                              41
       80                              41
       75                              41
       70                              41
       65                              42
       60                              42
       55                              42
       50                              42
       45                              43
       40                              43
       35                              43
       30                              44
       25                              44
       20                              45
       15                              46
       10                              48
       5                               52
```

FIGURE IV A-11
LOCATION 3
DATE 7/9/80
TIME 2040

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```
FILE MISS12.DA

OCTAVE BAND   LEQ       L         L         L         L         L         L
   HZ.         DB        1         10        50        90        95        99

   31.5       36        39        37        35        34        33        33
   63         40.7      42        41        40        39        39        39
   125        31.8      35        33        31        28        28        27
   250        24.8      26        25        25        24        24        24
   500        25.6      31        26        25        25        25        24
   1000       27.1      38        26        25        24        24        24
   2000       29.2      39        29        27        27        27        27
   4000       36.4      39        38        36        34        34        34
   8000       46.1      48        47        46        45        45        45
   A-WT.      47.5      49        48        47        47        46        46
```

A-Weighted
Sound Level -
dB re: 20µPa

```
 45   *  0.1 %
 46   *********  8.6 %
 47   ****************************************************  51.6 %
 48   ********************************  31.2 %
 49   *********  8.3 %
 50   *  0.1 %
 51
 52   *  0.1 %

EQUIVALENT SOUND LEVEL =  47.5  DB

              CUMULATIVE DISTRIBUTION

      (%) EXCEEDED           SOUND PRESSURE LEVEL-DB
          95                          46
          90                          47
          85                          47
          80                          47
          75                          47
          70                          47
          65                          47
          60                          47
          55                          47
          50                          47
          45                          47
          40                          47
          35                          48
          30                          48
          25                          48
          20                          48
          15                          48
          10                          48
          5                           49
```

FIGURE IV A-12
LOCATION 3
DATE 7/8/80
TIME 2345

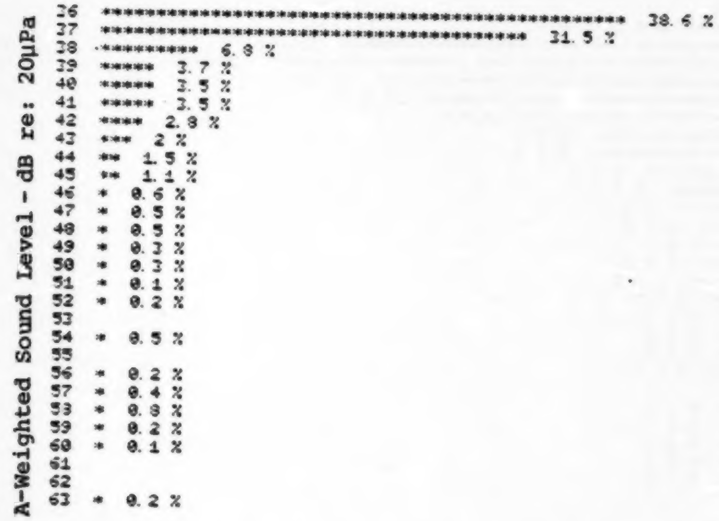
```
FILE MISS14.DA

OCTAVE BAND    LEQ        L          L          L          L          L          L
  HZ.          DB          1          10         50         90         95         99

  31.5         47.9       58         50         44         38         37         35
  63           53.6       64         54         51         51         50         50
  125          48.7       60         50         42         39         39         37
  250          40         52         39         35         34         34         34
  500          37.5       49         35         34         34         34         34
  1000         36.4       47         35         34         34         34         34
  2000         35.9       45         37         34         34         34         34
  4000         35.9       44         37         34         34         34         34
  8000         34.9       37         35         34         34         34         34
  A-WT.        42.7       54         45         38         36         36         35
```

A-Weighted Sound Level - dB re: 20μPa

```
35  ****  1.6 %
36  ************************************  16.2 %
37  *******************************************  19.2 %
38  *********************************  14.6 %
39  ****************************  12.5 %
40  ********************  8.9 %
41  *************  5.5 %
42  *************  5.5 %
43  ********  3.3 %
44  ******  2.5 %
45  *****  2.2 %
46  ***  1.4 %
47  ***  1 %
48  ***  1.3 %
49  ****  1.5 %
50  **  0.5 %
51  *  0.2 %
52  *  0.5 %
53  *  0.4 %
54  **  0.7 %
55
56  *  0.1 %
57  *  0.1 %
58  *  0.2 %
59  *  0.1 %
60  *  0.1 %

EQUIVALENT SOUND LEVEL =  42.7  DB

          CUMULATIVE DISTRIBUTION

   (%) EXCEEDED            SOUND PRESSURE LEVEL-DB
       95                          36
       90                          36
       85                          36
       80                          37
       75                          37
       70                          37
       65                          37
       60                          38
       55                          38
       50                          38
       45                          39
       40                          39
       35                          40
       30                          40
       25                          41
       20                          42
       15                          43
       10                          45
       5                           48
```

FIGURE IV A-13
LOCATION 4
DATE 7/9/80
TIME 1100

```
FILE MISS05.DA

OCTAVE BAND   LEQ        L         L         L         L         L       L
   HZ.         DB         1         10        50        90        95      99

  31.5        48.6       60        51        43        37        36      34
  63          51.5       57        52        51        50        50      50
  125         43.6       55        43        39        37        37      36
  250         40.4       47        36        34        34        34      34
  500         37.1       40        34        34        34        34      34
  1000        36.3       38        34        34        34        34      34
  2000        35.1       40        34        34        34        34      34
  4000        37.7       51        36        34        34        34      34
  8000        40.4       56        35        34        34        34      34
  A-WT.       43.6       58        42        37        36        36      36
```



```
EQUIVALENT SOUND LEVEL =  43.6  DB

            CUMULATIVE DISTRIBUTION

     (%) EXCEEDED           SOUND PRESSURE LEVEL-DB
         95                          36
         90                          36
         85                          36
         80                          36
         75                          36
         70                          36
         65                          36
         60                          37
         55                          37
         50                          37
         45                          37
         40                          37
         35                          37
         30                          37
         25                          38
         20                          39
         15                          41
         10                          42
         5                           45
```

FIGURE IV A-14
LOCATION 4
DATE 7/8/80
TIME 1430

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```
FILE MISS16.DA

OCTAVE BAND   LEQ      L        L        L        L        L        L
  HZ.          DB       1        10       50       90       95       99

  31.5        52.5     61       56       49       45       44       44
  63          61.5     67       61       61       60       50       50
  125         51.3     65       49       46       44       44       44
  250         46.5     55       46       44       44       44       44
  500         45.1     47       44       44       44       44       44
  1000        44.2     45       44       44       44       44       44
  2000        44.1     44       44       44       44       44       44
  4000        44.1     44       44       44       44       44       44
  8000        52.2     54       53       52       51       50       49
  A-WT.       52.9     59       53       53       51       51       50
```

A-Weighted Sound Level - dB re: 20µPa

```
50  ****  3.8 %
51  **********  9.7 %
52  ************************************  33.2 %
53  **************************************************  46.6 %
54  *****  4.5 %
55  *  0.3 %
56  *  0.5 %
57  *  0.1 %
58  *  0.2 %
59  *  0.2 %
60  *  0.4 %
61
62  *  0.4 %
63
64  *  0.1 %
65  *  0.1 %

EQUIVALENT SOUND LEVEL =  52.9  DB

           CUMULATIVE DISTRIBUTION

    (%) EXCEEDED            SOUND PRESSURE LEVEL-DB
         95                         51
         90                         51
         85                         52
         80                         52
         75                         52
         70                         52
         65                         52
         60                         52
         55                         52
         50                         53
         45                         53
         40                         53
         35                         53
         30                         53
         25                         53
         20                         53
         15                         53
         10                         53
         5                          54
```

FIGURE IV A-15
LOCATION 4
DATE 7/9/80
TIME 1900

```
FILE MISS01.DA

OCTAVE BAND   LEQ      L         L         L         L         L         L
   HZ.         DB        1         10        50        90        95        99

   31.5       39.1      40        42        36        35        34        34
   63         50.2      53        51        50        50        50        49
   125        38.8      49        41        35        34        34        34
   250        34.6      40        35        34        34        34        34
   500        34        35        34        34        34        34        34
   1000       34.3      39        34        34        34        34        34
   2000       34        35        34        34        34        34        34
   4000       44.1      46        46        44        42        41        38
   8000       55.1      56        56        55        54        54        54
   A-WT.      55.7      57        56        56        55        55        55
```

A-Weighted Sound Level - dB re: 20μPa

```
54  *  0.5 %
55  ************************************************  41.4 %
56  ************************************************************  51.5 %
57  ******  6.5 %

EQUIVALENT SOUND LEVEL =  55.7  DB

            CUMULATIVE DISTRIBUTION

     (%) EXCEEDED            SOUND PRESSURE LEVEL-DB
        95                            55
        90                            55
        85                            55
        80                            55
        75                            55
        70                            55
        65                            55
        60                            55
        55                            56
        50                            56
        45                            56
        40                            56
        35                            56
        30                            56
        25                            56
        20                            56
        15                            56
        10                            56
        5                             57
```

FIGURE IV A-16
LOCATION 4
DATE 7/7/80
TIME 2230

# TECHNICAL SUPPORT DOCUMENT V

## RADIOLOGY

# V RADIOLOGY

## 1.0 INTRODUCTION

### 1.1 SCOPE

This part of the Draft Environmental Impact Statement evaluates the radiological impacts of MCC's Hardee County phosphate mine. The evaluation was performed primarily by comparison of estimated concentrations of naturally occurring radionuclides in environmental media during and after implementation of the proposed actions to baseline concentrations. Special attention was given to radium-226 and its gaseous daughter, radon-222, which are the most mobile and the most hazardous of these radionuclides. Both the proposed method of sand-clay capping of waste slimes and tailings with minimum lake development and the conventional land and lakes disposal/reclamation methodologies were considered.

Particular concern has been expressed regarding the impacts of the proposed on-site drying of the phosphate rock product. The MILDOS computer code was used to estimate individual and population dose commitments resulting from mining operations with and without on-site rock drying.

An extensive radiological environmental monitoring program was conducted on the MCC property to determine baseline radionuclide concentrations in relevant environmental media. The results of this program are described in detail in Section 2.0 of this part and summarized in Section 3.6 of the DEIS. Appendix V-A describes sampling methodology and data analysis techniques.

Impacts of the proposed actions are analyzed in Section 3.0 and summarized in Section 3.6 of the DEIS. Particular attention is given to radiological impacts on air quality. Details of the air quality impact analysis are given in Appendix V-B.

## 1.2 SUMMARY OF BASELINE CONDITIONS AND RADIOLOGICAL IMPACTS

The findings of the baseline monitoring programs and impacts analysis are summarized below by environmental medium. Arithmetic averages are given unless stated otherwise.

### Terrestrial

The averaged measured radium-226 concentrations in the upper six feet of overburden, and overburden including leach zone, are 1.0 pCi/g and 6.2 pCi/g, respectively (Table V-1). The estimated external terrestrial gamma exposure rate at one meter above the surface is 1.8 μR/hr. The averaged measured radon flux of 0.37 pCi/m$^2$-sec is slightly less than the flux of 0.53 pCi/m$^2$-sec predicted from the measured soil radium concentration.

After conventional land and lakes reclamation, all parameters except one are estimated to increase slightly. The average radium concentration in the upper six feet of soil would increase to 3.4 pCi/g while that of soil in contact with the surficial aquifer (equivalent to overburden including leached zone above) would decrease to 5.1 pCi/g. The average external terrestrial gamma exposure rate would increase to 6.1 μR/hr while the average radon flux would become 1.2 pCi/m$^2$-sec.

For the proposed sand/clay cap waste disposal/reclamation method, all of these increases were less than or equal to those for the conventional method. Approximate impacts are shown in Table V-1.

### Air

Baseline airborne radium-226 and radon-222 concentrations average 0.30 fCi/m$^3$* and 0.36 pCi/liter, respectively (Table V-2). None of the proposed or alternative actions are expected to produce increases in concentrations of airborne radioactivity which are measurably above baseline concentrations. Individual dose commitments would be insignificant for the proposed and alternative actions.

---

*1 fCi = 0.001 pCi, 1 fCi/m$^3$ = 1 pCi/liter

Population dose commitments are summarized in Table V-3 for operational phase with and without rock dryer and for post-operational conditions. These commitments overestimate population doses by assuming that all food produced in the affected region is consumed by people living in the region. Population dose commitments would be highest after the site was reclaimed.

### Aquatic

Baseline concentrations of dissolved radium-226 average 0.6 pCi/liter in surface waters and 5.2 pCi/liter in the surficial aquifer. No increase in dissolved radium-226 concentration is expected for surface water and surficial aquifer. Radium concentrations in the surficial aquifer might actually decrease.

## 1.3 CONCLUSIONS

The only potentially significant impact of the proposed mining and reclamation plan would be that external terrestrial gamma exposure rates on reclaimed slimes disposal areas might exceed the USEPA guideline of 10 μR/hr, including background. The total estimated exposure rate (including background) on these areas would be 13.9 μR/hr for conventional waste disposal and 12.3 μR/hr for the proposed sand/clay cap disposal method. The USEPA guidance is intended to prevent excessive exposure to radon daughters (measured in units of working levels, WL) in structures which might be built on reclaimed lands and assumes 8,760 hour/yr exposure (100 percent occupancy). Thus, the estimated exposure rate is significant only if structures are actually erected on the reclaimed land.

Cost-benefit considerations suggest that each future construction site be considered on an individual basis rather than initiating mitigating action during reclamation. Gamma exposure rates are only an indication of radon daughter working levels. Measurement of radon flux on each site prior to construction would more accurately define whether a need for corrective action existed. Fluxes leading to exposures greater than the USEPA standard of 0.020 WL could be reduced, when necessary, by using topsoil to cover the site in question. Such mitigative action would be inexpensive when performed in conjunction with normal landscaping.

A second source of possible public concern are radioactive emissions from the proposed phosphate rock dryer. On the basis of a detailed analysis of both airborne particulates and radon gas emissions, it was concluded that on-site drying of rock would produce no detectable increase in airborne radium-226 and radon-222 concentrations. Therefore, operation of a rock dryer would not adversely affect public health.

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# 2.0 EXISTING CONDITIONS

## 2.1 INTRODUCTION

The purpose of pre-operational environmental monitoring is to establish the baseline conditions in existence at the site prior to commencing mining and associated activities. This information is necessary to properly estimate the effects of operations on the site environs and to provide comparison data for assessing the magnitude of the resultant environmental alterations after operations have ceased and the site has been reclaimed.

This section begins with an overview of the geologic and radiological characteristics of central Florida phosphate deposits and the general mining and beneficiation methods employed in that region. Site specific data are than presented for each of the media sampled during the baseline radiological study. Analytical results for measured parameters are compared with literature values to provide a perspective of site values relative to general or regional values.

## 2.2 RADIONUCLIDES IN PHOSPHATE

### 2.2.1 Ore Geology

Economically workable phosphate rock deposits occur as sedimentary phosphate, in igneous rocks, or as guano or deposits derived from guano (U.S. Bureau of Mines, 1978). Approximately 80 percent of world phosphate production and all phosphate rock mined in the United States is from sedimentary phosphorites (Stowasser, 1977). The term "phosphorite" refers to marine phosphate deposits (Bates, 1969).

The phosphate rock deposits of Florida are classified as land pebble deposits (pebbles and fine phosphate sand dispersed in a non-phosphatic sandy clay), hard rock deposits (phosphate-replaced limestone), soft rock deposits (phosphate sands and clays of the Alachua Formation), and river pebble deposits (phosphate nodules occurring in streams that have been winnowed from upstream or adjacent formations) (Bates, 1969; Zellars and Williams, 1978). Phosphate production in 1977 was predominantly from the land pebbles of the Bone Valley Formation in Polk, Hillsborough, and Hamilton Counties.

The Pliocene age Bone Valley Formation unconformably overlies the flat-lying Hawthorn Formation (also phosphate-bearing) of Miocene age. The lower and middle portions of the formation, which generally total 20 feet in thickness, are composed of poorly sorted clay, silt, and gravel (Bates, 1969). Gravel is predominant. All of the gravel and much of the sand and clay is composed of a carbonate fluorapatite.

The Bone Valley Formation is not predominant in the vicinity of the MCC site. The clayey phosphorite unit of the surficial deposits directly overlies the Hawthorn Formation (P.E. LaMoreaux and Associates, Inc., 1976) and contains the mineable phosphate ore or "matrix." The matrix on the MCC site contains almost no pebble, is generally low in phosphates, and has an average thickness of 50 feet.

### 2.2.2 Mining Methods

The Florida land-pebble deposits chiefly consist of the following four zones (Gieseke, 1976):

Overburden - This layer is generally from 6 to 50 feet thick and consists mostly of topsoil, clay, and sand. It may contain phosphate, but in minor amounts not currently recoverable economically. The bottom of the overburden layer generally includes a leach zone a few feet thick; where present, the leach zone on the MCC tract is 0 to 2 feet thick.

Matrix Ore - This zone contains the recoverable phosphates, mainly fluorapatite, with silica sand and clay minerals. The ore zone is usually from 3 to 30 feet thick; the ore zone averages 42 feet thick on the MCC site.

Bed Clay - This layer underlies the matrix and may contain minor phoshate values and limestone boulders.

Bedrock - This is usually a dolomitic limestone layer beneath the bed clay. The dolomite cannot be tolerated in the finished product.

As proposed by MCC, the overburden is stripped by large electric draglines and stacked on natural ground level adjacent to the cut, or cast into a previously mined-out cut. The draglines also mine the matrix, which is deposited in a nearby sluice pit. Water from high pressure guns (200 psi) is used to break down the friable ore into a slurry. The slurried matrix is pumped through pipelines at about 20 to 50 percent solids to the washing plant, which is usually not more than 3 miles away.

Phosphate values recoverable from the land-pebble deposits mined in central Florida are currently confined to the sands (+150 mesh -1 mm) and pebbles (+1 mm). The clay fraction (-150 or 200 mesh) contains approximately one-third of the total phosphate present in the ore matrix, but these values are not recoverable at present.

### 2.2.3 Radionuclide Contents of Subsurface Materials

Most phosphate deposits contain uranium series radionuclide concentations that may be significantly elevated above the mean value for the earth's crust. The higher uranium levels are associated with phosphorite deposits which, as previously stated, constitute all of the phosphate ores currently mined in the United States. Uranium substitutes for calcium in these phosphate deposits (Guimond and Windham, 1975).

Domestic ores generally contain between 50 and 200 ppm uranium on a dry weight basis (Guimond, 1977). This corresponds to 17 to 66 pCi/g of uranium-238, which is in radioactive equilibrium with its daughter products, at least through radium-226. Natural thorium activity is in the general range of normal background values, with concentrations ranging from 2 to 20 ppm (0.4 to 4 pCi/g).

Non-ore fractions may also contain elevated radionuclide concentrations. Topsoil may be slightly elevated above background due to deposition of daughter radionuclides from radon-222, which may diffuse upward from the ore body at rates higher than background (USEPA, 1978). Other non-ore fractions would contain uranium series activity similar to those reported for a typical profile from the central Florida phosphate district (USEPA, 1978). In this profile, uranium-238 activity was in the range of 5.6 to 8.4 pCi/g in the sand (upper) portion of the overburden, 28 to 84 pCi/g in the leach zone (lower) portion of the overburden, 5.6 to 42 pCi/g in the bed clay underlying the ore matrix, and less than 2.8 pCi/g in the bedrock. The ore matrix itself contained from 28 to 56 pCi/g of uranium-238 activity in its raw state.

### 2.2.4 Beneficiation Process

Slurried matrix is piped from the mine to the washer plant. The main functions of the washer plant are to remove the phosphate-bearing pebble from the matrix and to disaggregate the ore in water so that it can be separated from the phosphate-bearing fines. The components are separated by means of a series of vibrating screens in closed circuit with hammer mills and log washers.

Phosphate bearing pebble ($\geq$ 1 mm) is sent to open storage piles directly by conveyor or by in-transit railroad cars. The product may also be temporarily stored in bins for drainage. The undersized material is passed through a series of cyclones for dewatering and desliming. The waste slimes (- 150 mesh) are sent to holding ponds for disposal, the contained phosphate values being currently unrecoverable. The intermediate-sized sands ($<$ 1 mm, $\geq$ 150 mesh) are transferred to the flotation mill for separation of the phosphate minerals from the waste sand (tailings). Tailings may be slurried to separate sand piles, placed in mined-out areas, or used in the construction of dams to hold the slime ponds. The phosphate product is transferred to drainage bins, and the drained concentrate (80 to 86 percent solids) is sent to open wet-storage piles by conveyor. Some operations eliminate the drainage bins and send the concentrate directly to the storage piles.

The wet rock product, flotation concentrate or pebble is reclaimed from the storage piles by gravity-fed conveyors located in tunnels beneath the piles. The wet rock is dried in rotary or fluid bed dryers, or conveyed to grinding mills, then sent to storage silos. From the silos, the dry rock is transferred to chutes for loading into freight cars for shipment. Final destination may be nearby chemical plants, port facilities for water transport to more remote plants in the United States or for export, or end use consumers. The rock also may be shipped wet, or dry (but not ground), for final drying and/or grinding at an intermediate or final facility. There are many possible combinations in current usage.

### 2.2.5 Radionuclide Contents of Beneficiated Products and Wastes

The primary outputs of the beneficiation plant are the marketable phosphate rock or concentrate and the waste slimes and tailings. The general distribution of radionuclides in the three major fractions of phosphate ore matrix are presented in Table V-4. The uranium series nuclides appear to be in radioactive equilibrium through radium-226 in all three fractions. The distribution among fractions indicates that, assuming equal weights of materials, 45 percent of the uranium series activity is present in the marketable rock, 49 percent in the slimes, and 6 percent in the sand tailings.

### 2.2.6 Radon Emissions from Unaltered Lands

In a recent study (Roessler and others, 1978a) of the radon emissions from unaltered lands in Florida, radon fluxes were measured at 26 sites in three counties. Results are presented in Table V-5.

In addition to radon flux, Table V-5 presents data on surface soil and soil core radium-226 content and external gamma levels in an effort to correlate radon flux with these parameters. The best correlation was between the soil radium profile and the radon flux. Results yielded "rule-of-thumb" predictors of radon flux based on the average radium-226 concentration in a 6-foot core. These predictions are presented in Table V-6 for unaltered lands and mining products and by-products.

## 2.3 RADIOLOGICAL BASELINE MONITORING PROGRAM

The radiological baseline monitoring program is designed to determine existing concentrations of radioactivity in environmental media. The baseline concentrations form the basis for the assessment of the impacts of mining, waste disposal and reclamation activities at the site. The radiological baseline monitoring program is summarized in Table V-7. The program combines results obtained by an earlier study conducted by Environmental Science and Engineering, Inc. (1977) during the period December 1975 through March 1977 with those obtained during a second program conducted in 1980. Table V-8 describes the sampling locations for all the programs, and Table V-9 shows the correspondence of the sample numbering systems used in these studies. Sample locations are also presented graphically on Figure V-1.

The activity concentrations of those radionuclides having the most significant impact on public health were monitored in air, soil, water, vegetation, and sediment. These radionuclides are uranium-238, the parent of the uranium decay series (Table V-10), and its daughters, radium-226 and radon-222. The importance of uranium-238 is due to its position as parent of the series and its abundance in phosphatic materials. Radium-226 is important because of its long biological half-life (it replaces calcium in bone) and its high toxicity. Radon 222, the gaseous daughter of radium-226, also has a high toxicity, primarily due to its alpha-emitting daughters which are inhaled along with the parent gas.

The thorium decay series (Table V-11) includes an isotope of radon and two isotopes of radium. These isotopes are not significant since the activity in phosphatic materials of the series parent, thorium-232, is only 2 to 6 percent of that of uranium-238 (Guimond and Windham, 1975).

The results of the air monitoring and water monitoring programs are described in Section 2.6 and Section 2.7, respectively. The results of the terrestrial monitoring program are separated into subsurface radiation (soils), discussed in Section 2.4, and terrestrial radiation (ambient gamma radiation and vegetation), discussed in Section 2.5.

## 2.4 SUBSURFACE RADIOACTIVITY

A generalized hydrogeologic cross section of the MCC site is shown on Figure V-2. The majority of the phosphatic radioactive materials are found in the surficial deposits and the Hawthorn Formation. The highest levels of radioactivity in the Hawthorn Formation occur at depths of 150 to 200 feet. Mining activities at the site will disturb only the upper 100 feet of the surface so that little, if any, of the material in the Hawthorn Formation will be redistributed.

As shown on Figure V-3, the disturbed region is composed of several types of material. The upper 15 to 20 feet consists mainly of unconsolidated, fine to medium-fine grained, medium-sorted, unconsolidated quartz sands (P.E. LaMoreaux and Associates, Inc., 1976). These surficial sands and the overlying topsoil contain little or no phosphate and little radioactivity. The surficial sands are underlain by a thin layer of leached phosphate gravel and pale, greenish-yellow clay. This layer, called the leach zone, is depleted in calcium phosphates but contains relatively high levels of radioactivity. Below the leach zone and extending to a depth of about 100 feet is the phosphate ore body or matrix. The matrix consists primarily of white to greenish-green, plastic clay and becomes more calcareous with depth. It also contains moderate to minor amounts of black and light grey and reddish-brown phosphate sand and gravel and smaller quantities of quartzose sands. The matrix found on the MCC site differs from matrices typically found in Polk and Hillsborough Counties in that it is unusually thick (average thickness is 50 feet), with relatively thin overburden; it contains only a small amount of phosphate pebble and is generally low in phosphate.

To assess the radioactivity of these subsurface materials, composited core borings from five locations on the MCC site were obtained from Zellars-Williams, Inc. (Thomas, 1980).

### 2.4.1 Gamma Profiles

Gamma logs of boreholes are a useful guide to relative radium-226 concentrations as a function of depth. Since gamma logs were not available for the five soil core locations, the direct gamma radiation level at contact for each composite sample obtained from Zellars-Williams was measured using an Eberline PRM-7 Gamma Survey Meter. All readings were taken inside a 2-inch lead shield. The data obtained are compiled in Table V-12 and represented graphically on Figure V-4. A high degree of variability in gamma activity is readily apparent as a function of depth at each location and as a function of location. Such variation is typical of Florida phosphate deposits (Roessler and others, 1978b).

It should be noted that the highest gamma activities in each borehole occur within the surficial aquifer (Section 2.7). This suggests that radionuclide contamination of the surficial aquifer may be a continuous, natural process.

### 2.4.2 Radium-226 and Natural Uranium Profiles

In the central Florida phosphate district, radium and uranium concentrations are generally low at the surface and gradually increase with depth in the overburden. Concentrations increase more rapidly in the upper levels of the matrix. The leach zone, if present, normally contains high concentrations of radium and uranium. A typical radium-226 profile is shown on Figure V-5. It is generally accepted that uranium-238 is in secular equilibrium with its daughters through radium-226 in the matrix and beneficiation products and wastes (Guimond and Windham, 1975; Prince, 1977; Texas Instruments, Inc., 1978).

The composite samples obtained from Zellars-Williams were combined into samples representing the overburden, leach zone and matrix at each location and analyzed for natural uranium and radium-226. The results are presented in Table V-13 and represented graphically on Figures V-6 and V-7. Although the combining of composited samples caused some loss of detail, it is clear that the radium and uranium concentrations follow expected trends, reaching their highest values just above or in the matrix.

A comparison of the radium-226 concentrations of subsurface materials from the MCC site to those in other Florida phosphate regions is presented in Table V-14. Results show that the Ra-226 content of the overburden sampled at the MCC site is typical of mining lands in Florida. Matrix Ra-226 values are somewhat lower at the MCC site, as expected from the lower phosphate content of the MCC matrix. The radium-226 activity of the leach zone is, however, somewhat higher than the geometric mean for central Florida.

The geometric means in Table V-14, for all materials other than the matrix, are means based on the number of samples taken at each site. The matrix means, however, are depth-weighted averages (i.e., average Ra-226 content of the total material thickness sampled). When the MCC data are depth-weighted, the means (in units of pCi/g dry) become: 1.0, upper layer of overburden; 4.0, overburden (surface to top of leached zone); 23.9 leach zone; 6.2, overburden (surface to matrix); and 5.5, matrix (value in Table V-14 is already depth weighted). The depth-weighted means are more useful in comparing the overall radium content of the materials which will be disturbed by mining activities. When compared on this basis, the radium-226 contents of the overburden and matrix are approximately equal for the MCC site.

## 2.5 TERRESTRIAL RADIATION

The main emphasis of the terrestrial monitoring program was the determination of baseline ambient gamma radiation levels and baseline radium-226 concentrations in citrus crops and pasture vegetation.

Ambient gamma radiation levels (Section 2.5.1) are the sum of radiations from several sources. The primary sources are cosmic

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radiation and radiation emitted from the upper few feet of soil by the uranium and thorium decay series, and by potassium-40. Direct gamma radiation from airborne daughters of radon-222 and from airborne soil particulates is usually combined with direct radiation from soil and referred to as external terrestrial radiation. As seen in Table V-15, the contributions of cosmic and external terrestrial radiation are nearly equal and amount to about two-thirds of the average annual exposure from natural sources. The average values given in Table V-15 are weighted to account for variations in population density and altitude. Since the central Florida phosphate district is near sea level, exposure due to cosmic radiation is expected to be lower than the national average. Even though the phosphate matrix contains elevated levels of the uranium decay series, the depth of the matrix is generally such that elevated gamma radiation is not seen at the surface. The surficial aquifer also provides additional shielding.

The third major source of natural radiation exposure is from internally deposited radionucludes. Ingestion of foods and water containing members of the uranium and thorium decay series and inhalation of radon-222 gas and its daughters are the major contributors to the internal terrestrial dose. These sources were roughly assessed for the MCC site by measuring the radium-226 concentrations in citrus crops and pasture vegetation, as discussed in Section 2.5.2, and by measuring airborne radioactivity, as discussed in Section 2.6.

Average per capita doses from man-made sources are also presented in Table V-15 for comparison. It is readily seen that medical exposures account for over half of the annual per capita does.

### 2.5.1 Ambient Gamma Radiation Levels

Ambient gamma radiation was monitored on a monthly basis at seven on-site locations and three off-site locations by Environmental Science and Engineering, Inc. (1977) using thermoluminescent dosimeters (TLD's). The data obtained during the 12-month monitoring program are presented in Table V-16. Conversion of monthly data to annual exposures shows ambient gamma levels which average 31.4 mrem/yr (3.6 μR/hr) at on-site locations and 31.5 mrem/yr (3.6 μR/hr) at off-site locations. The highest annual ambient gamma level of 35.9 mrem/yr (4.1 μR/hr) was measured off-site in Wauchula, Florida. These levels are low compared to the national average dose from ambient gamma radiation (cosmic and external terrestrial radiation) of 75 mrem/yr (8.5 μR/hr) but are not inconsistent with the range of 35 to 70 mrem/yr (4 to 8 μR/hr) reported for Florida phosphate regions by Roessler and others (1978b).

### 2.5.2 Vegetation

Radioactivity in soil is absorbed by plants and may be ingested directly or indirectly by man. Consumption of fruits and vegetables are examples of direct ingestion while consumption of beef and dairy products are examples of indirect ingestion. Many processes are involved in the uptake of radioactivity from soils by plants. For a given plant type and radioactive chemical species, uptake is strongly influenced by soil chemistry.

To assess current levels of radioactivity in vegetation on the MCC site, radium-226 concentrations in citrus crops and pasture vegetation were measured. The results are given in Table V-17.

## 2.6 RADON FLUX AND AIRBORNE RADIOACTIVITY

### 2.6.1 Radon Flux

Radon originates from the decay of radium in soil and rock. The gas emanates from the ground at a rate dependent upon the permeability of the ground cover, soil moisture content, meteorological conditions, and other variables. The overall average radon emanation rate has been reported equal to 0.42 pCi/m$^2$-sec for the continental United States (National Council on Radiation Protection and Measurements, 1975). More localized data from the central Florida phosphate region (Table V-5) has yielded a geometric mean flux of 0.3 pCi/m$^2$-sec for the combined areas of Alachua, Hamilton, and Polk Counties.

Site-specific data reported in Table V-18 was obtained during two seasons at sampling location No. 15 on the MCC site. Results of sampling and analysis (see Appendix V-A for methodologies) yielded an overall mean for 10 measurements of 0.37, with a standard deviation of 0.21 pCi/m$^2$-sec. The geometric mean equaled 0.30 pCi/m$^2$-sec, identical to that of the 26 measurements reported in Table V-5 for unaltered lands.

Wet season measurements averaged 50 percent of the dry season measurement, which is to be expected based on the flux suppressing effect of soil moisture. The monthly rainfall actually experienced at the site is presented graphically on Figure V-8, which also includes a comparison with the expected monthly rainfall based on 36 years of data. Although 1980 was a somewhat atypical year in terms of monthly rainfall, May and October were representative of wet and dry season rainfall amounts, respectively.

### 2.6.2 Ambient Air Radon Concentration

The ambient air concentration of radon-222 at a particular point at ground level is dependent upon the radon source strength (flux) and subsequent atmospheric dispersion. Because of the long half-life of radon-222 (3.8 days) relative to air mass movements, localized ambient air radon concentrations are due primarily to the large land area sources upwind of the measurement point and hence are relatively insensitive to localized variations in radon flux. It is therefore difficult to correlate local air concentrations with local emanation rates, unless strong local radon sources (e.g., uranium mill tailings pile) exist just upwind of the measurement point. Background conditions at the MCC site are thus more area specific than site-specific.

A recent study (USEPA, 1979) reports a large number of ambient air radon measurements (grab samples) for three areas in Florida (Bartow, Orlando, and Jacksonville). These values are given in Table V-19, which shows a range of 0.02 to 0.28 pCi/liter for the six averages. The typical background range reported for the U.S. is 0.01-1.0

pCi/liter (National Council on Radiation Protection and Measurements, 1975).

Radon measurements were taken at three locations on the MCC site during the wet and dry seasons. Samples were collected as three consecutive 48-hour composites using the methods described in Appendix V-A. Results are reported in Table V-20. Wet season results were generally lower than the lower limits of detection, which averaged 0.34 pCi/liter. The LLD attained during dry season sampling was about half that of the wet season as a result of using newer scintillation cells that exhibited lower backgrounds.

The dry season concentration averaged 0.43 pCi/liter, with a standard deviation of 0.17 pCi/liter and a range of 0.17 to 0.70 pCi/liter. These results are consistent with typical values for the United States but appear slightly above the values given in Table V-19 for three locations in Florida. Other measurements taken in Polk County (Windham and others, 1978), however, indicate a range of 0.5 to 1.5 pCi/liter for outdoor radon concentrations. Therefore, it can be generally concluded that measurements indicate that site specific radon concentrations are consistent with previously reported values.

### 2.6.3 Airborne Particulates

Airborne particulates were sampled at three locations on the MCC site for one week each during the wet and dry seasons. Sampling methodology is described in Appendix V-A, and results of radium-226 analysis are presented in Table V-21. The average radium-226 concentration for the three sites is about 0.3 $fCi/m^3$ ($fCi = 10^{-15}$ curies). This is consistent with results reported for Polk County (USEPA, 1979) where a mean of 0.48 $fCi/m^3$ was obtained. Results of analysis for additional radionuclides in air were also reported in that study and are given in Table V-22 for reference.

## 2.7 RADIOLOGICAL WATER QUALITY

Site surface and ground water systems are described in detail in the ADA/DRI (MCC, 1977). All drainage from the site flows to the Peace River, mainly through Horse Creek which does not flow through the site. Streams in the vicinity of the site are shown on Figure V-1. Most runoff from the site is carried by Brushy, Oak, and Hickory Creeks. Lettis Creek joins Brushy Creek about 0.6 miles north of the site. None of the on-site steams cuts deeply enough to expose the phosphate matrix, and all are intermittent, deriving 25 to 40 percent of their annual flows from the surficial aquifer.

The surficial aquifer lies within the upper sandy unit (overburden) of the surficial deposits (Figures V-2 and V-3) and has an average thickness of about 20 feet. Several domestic wells in the community of Ona and surrounding areas tap the surficial aquifer for potable water. Underlying the surficial aquifer are the clayey phosphorite unit of the surficial deposits and the upper part of the Hawthorn Formation, which form the upper confining bed of the Upper Floridan aquifer. The Upper Floridan is an artesian aquifer composed of permeable limestones of the Hawthorn and Tampa Formations. It is separated from the Lower Floridan aquifer by the sand and clay unit of the Tampa Limestone. The Lower Floridan aquifer consists of limestone and dolomitic limestone of the Suwanee, Ocala, and Avon Park Groups.

It is extremely unlikely that any contaminated waters resulting from mining activities on the MCC site will reach either unit of the Floridan aquifer because of the thickness and low permeabilities of the confining beds. It is possible, however, that pumping of the Lower Floridan aquifer may alter the radioactivity of that aquifer as the aquifer recharges with water (of differing radionuclide content) from areas outside the site boundaries. Redistribution of surficial deposits and waste disposal practices will cause dramatic changes in the surficial aquifer, surface streams, and drainage patterns on the site.

Establishing baseline radiological conditions thus involves measurement of the radionuclide concentrations (i.e., radium-226) in surface water, stream sediments and ground water, as discussed in Sections 2.7.1, 2.7.2, and 2.7.3, respectively.

### 2.7.1 Surface Water

Surface water samples were collected monthly by Environmental Science and Engineering, Inc. (1977) during the period December 1975 through March 1977 and analyzed for gross alpha activity in suspended and dissolved solids and for dissolved radium-226. The results are presented in Table V-23. Comparison of the geometric mean results by sampling locaton does not reveal any significant differences among locations. The few elevated gross alpha activities are probably due to elevated solids loading of runoff during periods of heavy precipitation. The radium-226 activity of 3.4 pCi/liter in a sample from Troublesome Creek may be due to the high dissolved solids content which prevented measurement of gross alpha activity (Environmental Science and Engineering, Inc., 1977). Comparison of the MCC data with typical local and non-local values given in Table V-24 shows that radium-226 concentrations in site surface waters are somewhat lower than those in other areas of the Peace River Basin, Lithia Springs, and Hookers Prairie. However, on the average, MCC values fall approximately on the mean of the nine values reported for Florida locations in Table V-24. The five values reported on that table for out-of-the-state surface waters are for general comparison.

### 2.7.2 Stream Sediments

Sediments collected at the site inflow and outflow of Brushy and Oak Creeks were analyzed for radium-226. The results presented in Table V-25, show radium-226 concentrations somewhat lower than those typically found in surface soil (Table V-14). The slight difference in concentrations seen in Brushy Creek sediments is not considered significant.

### 2.7.3 Ground Water

The concentration of dissolved radium-226 in central Florida ground water has been the subject of numerous studies. Data obtained in programs conducted by the USEPA and USGS are compiled in Table V-26. Of particular interest here are radium-226 activities in unmined mineralized areas. These data indicate that the average radium-226 concentration is highest in the Upper Floridan aquifer (2.86 pCi/liter) and about an order of magnitude less in the surficial aquifer (0.22 pCi/liter). The concentration in the single MCC sample taken from the Upper Floridan aquifer (Table V-27) is higher than the average but within the range of values reported in Table V-26. Site data for the Lower Floridan aquifer are very close to the mean value for central Florida.

Results of analyses of ground water samples collected during the aquifer testing program and the baseline monitoring program are presented in Tables V-27 and V-28, respectively. The geometric means of Ra-226 values for the surficial aquifer obtained during the aquifer testing program and baseline monitoring program are 3.2 pCi/liter and 1.7 pCi/liter, respectively or an overall geometric mean of 2.2 pCi/liter. These means are somewhat higher than the mean for unmined mineralized areas, although 12 of the 13 reported values are within the typical range for these areas. The one radium-226 concentration in the surficial aquifer above the typical range may be related to the elevated radium-226 content of the leach zone as discussed in Section 2.4.2. It should be noted that radium-226 concentrations in drinking water samples from wells taping the surficial aquifer were all below the USEPA Drinking Water Standard of 5.0 pCi/liter (USEPA, 1976).

# 3.0 IMPACTS OF PROPOSED OPERATIONS

## 3.1 CONVENTIONAL WASTE DISPOSAL/LAND AND LAKES RECLAMATION

### 3.1.1 Introduction

Mining and reclamation operations would increase radiation levels in certain environmental media and, in some cases, might result in increased radiation exposure for people living in the vicinity of the site. A detailed analysis was performed for the conventional (separate sand and clay wastes) waste disposal method, with land-and-lakes reclamation, to identify those areas where radiation levels could be expected to increase and to estimate the magnitude of the increase. An assessment was made of the impacts of these increases on radiation levels by estimating the magnitude of any resulting increases in the radiation dose received by people living in the vicinity of the site and by comparison with applicable standards and recommendations.

The source of any increase in radiation dose would be the redistribution of the radioactivity contained in materials which presently lie below the surface of the property. This redistribution is described in Section 3.1.2.

As mining and reclamation proceed, the total amount of radioactivity on the site would decrease since a substantial fraction would be shipped off-site with the product. However, the remaining radioactivity would become more accessible to the environment. Gamma radiation levels would increase slightly (Section 3.1.3) as deeper layers of overburden were brought to the surface and waste slimes were disposed of in impoundments. The change in surface radioactivity would cause an increase in radon flux (Section 3.1.4.2). Dragline operations and product drying and handling would cause temporary increases in the concentrations of airborne particulates and radon while reclamation of waste disposal areas would result in a slight but permanent increase in airborne radon concentrations. Airborne radon concentrations are discussed in Section 3.1.4.2 and particulates in Section 3.1.4.3.

The radioactivity of surface waters (Section 3.1.5.1) might be increased by runoff from impoundment dikes and, due to the high water table, by seepage from the impoundments. This seepage might also increase the radioactivity of the surficial aquifer (Section 3.1.5.3). Pumping of the Floridan aquifers might increase their radioactivity as they recharge. However, the thickness of the confining bed underlying the MCC property makes recharge from the surficial aquifer extremely unlikely.

### 3.1.2 Redistribution of Sub-Surface Radioactivity

Mining and beneficiation would be accomplished using the standard techniques described in Section 2.1 and 2.4 of the DEIS. Two large draglines would strip the overburden, spoiling it in previously mined pits, and mine the matrix. Active pits would be pumped to minimize accumulation of standing water. The matrix would be deposited in nearby sluice pits, slurried with high pressure water, and pumped through a pipeline to the washer plant.

The slurried matrix would be separated at the washer plant into three fractions, based on particle size: pebble (>1 mm), sands (<1 mm, >150 mesh), and slimes (<150 mesh). Pebble collected by screens would be routed to the wet product pile or waste pebble pile, depending on its grade. Slimes would be separated from sands by centrifugal devices and would be pumped at 3 weight percent solids to settling areas. Most of the water seeping from these areas would be collected by ditches and returned to the plant. The slimes would eventually settle to about 30 weight percent solids.

The sand-sized fraction would be fed to the flotation circuit where phosphatic sands would be separated from silica sands. The phosphatic sands (concentrate) would be routed to the wet product storage piles while the silica sand tailings would be used for dam construction and land reclamation. Again, most of the water released from these materials would be collected and reused in the plant.

As reclamation proceeded, settled slimes and tailings used as fill would be covered with overburden caps. These caps would allow revegetation of such disposal areas but, as indicated in Table V-29, would increase the radioactivity of surface materials relative to both baseline conditions and the bare waste materials. For the purpose of this analysis, it is conservatively assumed that the overburden caps would include higher activity material from the leach zone.

The radionuclide concentrations given in Table V-29 are the basis of the impacts analysis. Appendix V-B describes the methods used to estimate these concentrations. Radium-226 concentrations are of particular concern since radium is toxic itself and is also the source of highly mobile radon-222 gas and the gamma-emitting radionuclides responsible for the majority of the external terrestrial radiation dose.

### 3.1.3 Impacts on Ambient Gamma Radiation Levels

Ambient gamma radiation levels are normally measured using gamma scintillometers (portable survey meters), ionization chambers, and thermoluminescent dosimeters (TLDs). In this application, these devices are placed one meter above the ground surface, where they sense gamma-emitting radionuclides in soil and air (external terrestrial radiation), as well as cosmic radiation. Cosmic radiation contributes about 31 mrem/yr or 3.5 μR/hr (Table V-15), while the external terrestrial component averages 24 mrem/yr or 2.7 μR/hr (National Council on Radiation Protection and Measurements, NRCP, 1975).

The baseline ambient gamma level of 31.4 mrem/yr (Section 2.5.1) measured using TLD's does not reflect the absence of an external terrestrial component but rather a common feature of TLD measurements. TLD's are normally accompanied by control TLD's when shipped to and from the laboratory. The controls are placed in a lead shield while the rest are in the field so that the dose received by the field TLD's during shipment can be subtracted. The lead shield stops virtually all of the terrestrial radiation but allows a fraction of the cosmic radiation to penetrate so that the calculated net dose is somewhat lower than the sum of the cosmic and terrestrial components. Thus, while TLD measurements during mining and reclamation will accurately measure any increase in external terrestrial radiation, they do not, under these conditions, allow direct measurement of the baseline.

This difficulty can be circumvented by using the measured baseline radium-226 concentration of 1.0 pCi/g (Section 2.4.2) in the upper six feet of overburden. The NRCP (1975) gives a conversion factor of 1.8 μR/hr per pCi/g of radium-226 in the infinitely-thick homogeneous radium-containing soil. This conversion yields a baseline external terrestrial gamma dose of 1.8 μR/hr.

The external terrestrial dose after reclamation (Table V-30) can be estimated using the conversion factor, radium-226 concentrations given in Table V-29, and areas of each type of reclaimed land given in Table V B-6. Radium-226 concentrations are expected to average 3.4 pCi/g and range from 1.0 pCi/g for undisturbed areas to 5.8 pCi/g for capped slimes. The corresponding external terrestrial dose would average 6.1 μR/hr and would range from the present level of 3.4 μR/hr to a high of 10.4 μR/hr. The contribution from airborne and deposited particulates would be neglible (Section 3.1.4.3).

Although the site average external gamma radiation level would be below applicable recommendations, the level of reclaimed clays would be slightly above the USEPA (1976) recommended level of 10 μR/hr but well below the maximum level of 20 μR/hr being considered by the State of Florida (Florida Department of Health and Rehabilitative Services, FDHRS, 1980). Both recommended limits are designed to prevent excessive exposures to radon-222 and its daughters in structures built on reclaimed lands (Section 3.1.4.2).

### 3.1.4 Impacts on Air Quality

This section discusses the radiological impacts of the proposed actions on air quality. Since elimination of on-site product drying is the only alternative having a significant effect on air quality, the impacts of this alternative are also discussed here. The discussion focuses on the results of the calculations described in Appendix B.

### 3.1.4.1 Radon Flux

The radon fluxes of the product and various surficial materials estimated in Appendix V-B are summarized in Table V-31. The flux from reclaimed waste disposal areas is expected to average two to four times the baseline flux. The fluxes of reclaimed waste disposal areas are within the range of $<0.1$ to 3.2 pCi/m$^2$-sec measured for undisturbed lands (Table V-5). When the natural variation in radon flux and measurement uncertainties are considered, it is unlikely that the small increase from reclaimed tailings could be measured. In any case, the mean flux of reclaimed materials would be substantially less than the limit of 3 pCi/m$^2$-sec above natural background being considered by the State of Florida (FDHRS, 1980).

The complex relationship between radon flux and indoor radon daughter working levels (WL) continues to be an area of active research. The WL is useful in assessing the dose to the lung resulting from inhalation of radon daughters and is defined as any combination of short-lived radon daughters in 1 liter of air which, on complete decay, will produce $1.3 \times 10^5$ MeV of alpha energy.

Roessler (1978b) has developed equations to predict indoor working levels for slab-on-grade structures from three interrelated parameters: external gamma exposure rates (EG in μR/hr), soil radium-226 concentrations ($C_{Ra}$ in pCi/g), and radon flux (J in pCi/m$^2$-sec). These equations are:

$$WL = 0.0022\ (EG)^{1.01}$$

$$WL = 0.0065\ (C_{Ra})^{0.563}$$

$$WL = 0.0087\ (J)^{0.461}$$

Averaging the results of these three equations yields the estimates of indoor working levels given in Table V-32 for structures which may be built on the MCC property. The expected working levels are well within the range of values measured in Polk County.

Several limits on indoor total working levels have been proposed:

0.01 WL- Surgeon General's guideline
0.020 WL - USEPA, 1979
0.029 WL - FDHRS, 1978

The interim standards now being considered by the State of Florida (FDHRS, 1980) do not explicitly limit working levels. The USEPA (1979) estimates background at 0.009 WL (0.004 WL plus an uncertainty of 0.005 WL). Inclusion of this background would place indoor working levels above reclaimed slimes and tailings on the MCC property slightly above the USEPA guideline. The magnitude of the excess is such that corrective actions are not indicated prior to development of the land. Measurements of radon fluxes or soil Ra-226 concentrations after reclamation at a specific construction site should be taken to establish the need for corrective action. It should be remembered that the estimated working levels were based on the assumption that the reclaimed areas would be capped with four feet of overburden. Because the radium content of the overburden (including the leach zone) is higher than that of the underlying waste, working levels would be reduced by simply using thinner caps. After reclamation, adding topsoil over the capped areas would be effective in reducing radon flux and working levels.

### 3.1.4.2 Airborne Radon Concentrations

Estimated airborne radon concentrations and working levels at the MCC property boundary are presented in Tables V-33 through V-35. These concentrations were calculated by the MILDOS code, as described in Appendix V-B. Airborne radon concentrations would be zero for the operational phase without the rock dryer (Table V-34) since the radon flux in this case was assumed to be equivalent to baseline conditions. If the rock dryer were in operation, a maximum boundary radon concentration of 0.195 $pCi/m^3$ ($1.95 \times 10^{-4}$ pCi/liter) would occur at the north boundary location. Note that the highest working level ($6.99 \times 10^{-7}$ WL) would occur at the west boundary. The fact that the location with the highest airborne radon concentration and highest working level do not coincide is due to differences in the suspension

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characteristics of radon gas and its airborne daughters. During the post-operational phase (Table V-35), the maximum boundary airborne radon concentration of 57.5 pCi/m$^3$ (0.0575 pCi/liter) would occur at the southeast boundary location. Working levels would also be highest at this location (1.06x10$^{-4}$ WL).

Measured baseline airborne radon concentrations on the property range from 0.25 to 0.77 pCi/liter and average 0.36 pCi/liter. The rock dryer would have virtually no effect on airborne radon concentrations since the increase of 1.94x10$^{-4}$ pCi/liter caused by the rock dryer would not be detectable. The increase in the radon concentration of about 16 percent after reclamation would have a negligible impact (Section 3.1.4.4) and would not be detectable above the natural fluctuation in baseline radon concentrations.

### 3.1.4.3 Airborne Particulates

Airborne concentrations of radium-226 which would occur as a result of the alternative actions and ground concentrations resulting from deposition of these particulates are presented in Table V-33 through V-35. These concentrations would be zero for the post-operational phase since radon emanation from reclaimed lands was assumed to be the only source of airborne radioactivity above baseline levels.

Airborne radium-226 concentrations would be higher if the product were dried on-site (Table V-33) rather than at a remote location (Table V-34). In either case, the increases in airborne radium-226 concentrations would not be detectable above the natural fluctuation of the baseline airborne radium-226 concentrations, which average 0.3 fCi/m$^3$. (3x10$^{-4}$ pCi/m$^3$). The highest estimated concentration (0.028 fCi/m$^3$) would occur at the north boundary location; this would be only 10 percent of the baseline concentration and would yield a total radium-226 concentration, including baseline (background), which is still below the mean concentration of 0.48 fCi/m$^3$ measured in Polk County (Table V-22). If the product were not dried on-site, the highest radium-226 concentration (0.0099 fCi/m$^3$) would occur at the southeast boundary location and would represent a 3 percent increase over baseline concentrations.

The ground level radium-226 concentrations given in Tables V-33 and V-34 were calculated by MILDOS as the sum of the annual depositions over the 31.5-year life of the facility and have been corrected for decay (negligible) and washout by precipitation (about 50 percent reduction over 31.5 years). Again, deposition would be zero during the post-operational phase. Maximum deposition at the property boundary would occur at the southeast location in both operational cases and would amount to 216 pCi/m$^2$ for on-site and 148 pCi/m$^2$ for off-site product drying.

Since central Florida topsoil has an average radium concentration of 0.5 pCi/g (Table V-14) and a density of about 1.4 g/cc, the first centimeter of soil would contain about 7,000 pCi/m$^2$ of radium-226. The maximum ground concentrations, therefore, would result in increases of 3 and 2 percent for on-site and off-site drying, respectively. Such small increases are not expected to result in measurable increases in external terrestrial gamma exposure rates, soil radium-226 concentrations, or radon fluxes.

### 3.1.4.4 Annual Individual and Population Dose Commitments

The concentration data discussed in previous sections do not, by themselves, give a complete estimation of the impacts of airborne releases of radioactivity. Such an estimation can be made by calculating annual individual and population dose commitments. These commitments are calculated by integrating the dose resulting from a one year exposure over a 50-year period. Annual individual dose commitments based on the adult lung dose at the boundary locations and in Ona are given in Tables V-33 through V-35. Annual population dose commitments within an 80 km radius of the facility are summarized in Table V-3.

These dose commitments include the contribution of inhaled and ingested radioactivity as well as direct exposure from airborne and

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deposited radionuclides. The following radionuclides were included in the MILDOS calculations: U-238, U-234, Th-230, Ra-226, Rn-220, Po-218, Pb-214, Bi-214, Pb-210, and Bi-210. Not all radionuclides were included in all exposure pathways. The ingestion pathway included the major food groups (vegetables, meat, and milk) and considered both direct deposition and uptake from soil.

Individual dose commitments would be highest for the operational phase with on-site product drying (Table V-33) and lowest for the operational phase with off-site drying. Maximum individual dose commitments at the boundary would be 0.391 mrem/yr (N receptor) for on-site drying, 0.104 mrem/yr (SE receptor) for off-site drying, and 0.0447 mrem/yr (SE receptor) after reclamation. The highest of these three maxima is less than 0.5 percent of the annual dose to the general public from natural sources of 82 mrem/yr (Table V-15). Dose commitment calculations were also performed for a receptor located at the northwest corner of the community of Ona, which is within the property boundaries. Doses at this location would be below the maximum in all cases.

Population dose commitments are summarized in Table V-3. Population dose commitments would be highest during the post-operational phase due to the mobility of radon gas and the large radon source terms for this phase. Population dose commitments would be slightly less for the operational phase with on-site product drying and about a factor of 10 less for off-site drying. It should be noted that the relatively high population bone dose commitments would be due primarily to ingestion and would be overestimated by assuming that all of the food produced in the region was consumed by the 1.16 million people living within 80 km of the facility.

Individual or population dose commitments resulting from alternative product handling operations in Pascagoula, Mississippi were not estimated. The product processing rate would be about one-third the rate at Ona and the rock could be processed wet or dry. Source terms would be lower than at Ona. However, most of the radioactivity would be deposited near the facility regardless of location. Since the Pascagoula facility is located in an urban area, population doses might be higher in spite of the lower source terms and possibly lower individual dose commitments.

### 3.1.5 Impacts on Water Quality

This section qualitatively assesses radiological impacts on surface and ground water quality. Since radium-226 is the most hazardous and most soluble of the radionuclides found in phosphatic materials, impacts were assessed in terms of dissolved and suspended radium-226 concentrations. Radium-228, a descendant of thorium-232, was not considered since thorium-232 activities are only a few percent of U-238 activities in phosphatic materials (Table V-4).

#### 3.1.5.1 Surface Water

Baseline dissolved radium-226 concentrations were shown in Section 2.7.1 to be comparable to those found in other surface waters in central Florida. Dissolved radium-226 concentrations averaged 0.6 pCi/liter. Suspended radium concentrations were not measured; however, the average gross alpha activity of 1.2 pCi/liter for suspended solids may be taken as an upper limit. The total estimated baseline radium-226 concentration in surface water of 1.8 pCi/liter is well below the USEPA guideline of 9 pCi/liter for phosphate industry effluents.

The proposed water usage plan for the MCC facility was designed for maximum recycle of process water. There would be no planned discharges of process of effluents to surface waters although overflow from the clear water pond might occur during high rainfall periods. During such periods, dissolved radium-226 concentrations are expected to decrease in the settling and clear water ponds due to the rapid influx of diluting rainwater. Turbulence caused by this rapid influx is expected to increase the concentration of suspended solids which would be transported by overflow from the clear water pond to surface streams. An average of 30 mg/l of suspended solids, with a maximum of 60 mg/l, is expected in the clear water pond during overflow conditions. Based on a radium-226 concentration of 5.1 pCi/g in the slimes (Table V B-3), the source of the suspended solids, these solids loadings would yield an average suspended radium-226 concentration of only 0.15 pCi/l with a maximum of 0.30 pCi/l. Ignoring dilution, the dissolved radium-226 concentration is estimated at 0.7 pCi/l based on the slime effluent data of Guimond and Windham (1975). Thus, the maximum total radium-226 concentration in water released during overflow conditions is estimated to be 1.0 pCi/l. This is below the average total radium-226 concentration of 1.8 pCi/l observed during baseline monitoring of the streams draining the site.

It is possible that water seeping from slimes settling areas, seepage collection ditches, and process water holding ponds would, because of the high water table, reach surface waters. The suspended solids content of seepage reaching surface waters would be negligible after migration through soil, and dissolved radium-226 concentrations should be <2 pCi/liter (Guimond and Windham, 1975).

Runoff is another source of potential surface water contamination. During mining operations, much of the surface runoff would be collected in open mine pits, waste disposal impoundments, and seepage collection ditches. This water would enter the process water recycling system rather than surface waters. After reclamation, the slightly elevated radium-226 concentration of surface materials might cause a slight increase in concentrations in surface water. Data presented in Table V-24 for the Peace River Basin in Hillsborough, Polk, Manatee, and Hardee Counties, which drains large portions of the central and south Florida phosphate mining districts, indicate that any increases in surface water radium concentrations would be minimal.

### 3.1.5.2 Ground Water

Baseline monitoring data for dissolved radium-226 in ground water on the MCC property given in Tables V-27 and V-28 indicate that the surficial aquifer contains, as the result of natural processes, dissolved radium-226 in concentrations which are elevated with respect to other mined areas in central Florida (Table V-26). These observations may be related to elevated activity of the leach zone and relative thinness of the overburden on the MCC property.

The data presented in Table V-26 appear to show an elevation in ground water radium content as the result of mining mineralized areas; however, this conclusion cannot be drawn from the available data since these data do not compare concentrations before and after mining of a specific area.

The data given in Table V-29 show that the radium-226 concentrations of the materials in contact with the surficial aquifer would be lower after reclamation. The overburden, including the leach zone, now in contact with the aquifer contains a radium concentration of 6.2 pCi/g, while the surficial aquifer contains an average radium concentration of 5.2 pCi/liter. Taking into account the relative areas of reclaimed land types, the average radium concentration of materials in contact with the aquifer after reclamation would be 5.1 pCi/g. On the basis of the ratio of baseline ground water to soil radium concentrations, the ground water radium concentration would be expected to decrease to 4.3 pCi/liter after reclamation. While this approach ignores the mineralogy and size distribution of soils before and after reclamation and, therefore, cannot accurately predict future ground water radium concentrations, it does suggest that impacts on ground water would be minimal due to the overall reduction in radium content of the materials in contact with the surficial aquifer. Impacts on the Floridan aquifers due to recharge from the surficial aquifer are also expected to be minimal.

Although baseline dissolved radium-226 concentrations are somewhat elevated, concentrations in drinking water (Table V-28) are below the USEPA standard of 5 pCi/liter for combined radium-226 and radium-228 (USEPA, 1976). These drinking water samples were all taken from wells tapping the surficial aquifer. Since no increase in the radium concentrations of this aquifer is expected, drinking water concentrations should not be affected at the site.

## 3.2 SAND-CLAY CAP WASTE DISPOSAL (PROPOSED BY MCC)

### 3.2.1 Introduction

Due to concerns about the extensive above-ground clay disposal areas with the conventional waste disposal methodolgy, the land-and-lakes reclamation plan discussed in previous sections was replaced as the proposed project. The final, proposed reclamation plan would minimize above grade disposal of waste slimes by reducing the lake area to about 400 acres and creating near-grade slimes and tailings disposal areas on the remaining land affected. Although larger areas of the reclaimed site, as proposed, would consist of materials containing elevated concentrations of radium-226, the radium concentrations would be less than those estimated for land-and-lakes reclamation. This reduction is due primarily to differences in the materials used to cover disposal areas.

Because of the relatively thick matrix and thin overburden, the leach zone (where it exists) would be located in the bottom of mined pits; sand/clay caps and thinner overburden covers would be used for waste disposal areas. The sand/clay caps would be 4 feet thick and would consist of eight parts by weight tailings and one part by weight slimes. Overburden covers would result from spreading dikes and overburden piles over near-grade and below-grade disposal areas. Dikes would be constructed of a mixture of overburden and tailings. It was conservatively assumed that spreading would result in a uniform, one-foot thick cover consisting entirely of overburden. The resulting radiological characteristics of the final, reclaimed land types are summarized in Table V-36. Radon source terms are given in Table V B-12 (Appendix V-B). Comparison of Table V-36 with Tables V-29 through V-32 indicates that all relevant radiological parameters would be less than for land-and-lakes reclamation, which was shown in Section 3.1 to have no adverse effect on public health. The remainder of this section describes major impacts of the proposed waste disposal/reclamation plan in conjunction with other phases of the proposed action.

### 3.2.2 Reclaimed Land Use

As indicated by the total gamma exposure rates and indoor radon daughter working levels presented in Table V-36, a potential problem would exist if buildings were erected on sand-clay mix capped slimes. These areas might exceed the USEPA recommended total gamma exposure rate by 2.3 μR/hr and the recommended indoor working level by 0.004 WL (including background WL). These elevated levels are slightly less than those predicted for conventional waste disposal and land-and-lakes reclamation (Tables V-30 and V-32. As discussed in Section 3.1, the need for mitigating action should be determined by measuring radon flux at specific construction sites after reclamation. When necessary, topsoil covers could then be applied to attain the recommended levels. For example, two feet of topsoil with a radium-226 concentration of 0.5 pCi/g would reduce the total gamma exposure rate to 9.6 μR/hr and the estimated indoor working level to 0.02 WL.

### 3.2.3 Dose Commitments

Since the total radon source term would decrease from 965 Ci/yr for land-and-lakes reclamation (Table V B-8) to 561 Ci/yr for the proposed plan (Table V B-12), population dose commitments would also be substantially reduced. A reduction in population dose commitment of about 40 percent is expected. The magnitude of the maximum individual dose commitment at the boundary, and its location, cannot be predicted by simple inspection because of the proximity of the receptors to the four sectional radon sources and because the change in source strength is not the same for all sources.

### 3.2.4 Water Quality

#### 3.2.4.1 Surface Water

The radium-226 concentrations of surficial materials would be less for the proposed reclamation plan than for land-and-lakes reclamation; a corresponding decrease in the radium concentration of runoff would be expected. It is unlikely that the decrease would be measureable.

### 3.2.4.2 Ground Water

No change in ground water radium-226 concentration would be expected relative to that estimated for land-and-lakes reclamation since the radium concentrations of the materials in contact with the surficial aquifer would be unchanged.

## TABLE V-1

## SUMMARY OF TERRESTRIAL AND AQUATIC RADIOLOGICAL IMPACTS

| Medium | Baseline | Post-Reclamation |  |
|---|---|---|---|
|  |  | Conventional Land-and-Lakes | Sand-Clay Cap (MCC's Proposed Action) |
| Terrestrial |  |  |  |
| Overburden (0-6 ft.) |  |  |  |
| Radium-226 (pCi/g) | 1.0 | 3.4 | 2.8 |
| External Terrestrial Exposure Rate (μR/hr) | 1.8 | 6.1 | 5.0 |
| Radon Flux (pCi/m$^2$-sec) | 0.37 | 1.2 | 0.82 |
| Overburden in Contact with Surficial Aquifer (pCi/g) | 6.2 | 5.1 | 5.1 |
| Aquatic |  |  |  |
| Surface Water (Dissolved Ra-226, pCi/liter) | 0.6 | 0.6 | <0.6 |
| Ground water (Surficial Aquifer) (Dissolved Ra-226, pCi/liter) | 5.2 | 4.3 | 4.3 |

## TABLE V-2

## SUMMARY OF AIRBORNE RADIOLOGICAL IMPACTS

| | Airborne Ra-226 ($fCi/m^3$) | Airborne Rn-222 (pCi/liter) | Individual Dose Commitment[a] (mrem/yr) |
|---|---|---|---|
| Baseline | 0.30 | 0.36 | -- |
| Operational[b] | | | |
| Rock Dryer | 0.028 | $1.99\times10^{-4}$ | 0.39 |
| No Rock Dryer | 0.0099 | 0 | 0.10 |
| Post Reclamation[b,c] | 0 | 0.058 | 0.045 |

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[a] As increase above baseline based on adult lung and including contribution of inhalation, ingestion, and direct exposure.

[b] Maximum concentrations at property boundary expressed as increases above baseline concentrations.

[c] Calculated for conventional land and lakes reclamation. Concentrations for proposed sand/clay cap reclamation plan are expected to be approximately 40 percent lower; resulting dose commitments should also be lower.

## TABLE V-3

## SUMMARY OF ANNUAL POPULATION DOSE COMMITMENTS WITHIN AN 80 KM RADIUS OF THE PROPOSED MCC FACILITY

(Person Rem/Year)

| | Whole Body | Bone | Average Lung |
|---|---|---|---|
| 1. Operational Phase With Rock Dryer | | | |
| Inhalation | 6.89 E-2[e] | 2.20 E+0 | 3.11 E+0 |
| Ingestion[a] | 7.08 E-1 | 8.40 E+0 | 7.08 E+0 |
| Direct Exposure[b] | 2.92 E-1 | 2.92 E-1 | 2.92 E-1 |
| Total | 1.07 E+0 | 1.09 E+1 | 4.11 E+0 |
| 2. Operational Phase Without Rock Dryer[c] | | | |
| Inhalation | 2.05 E-3 | 5.89 E-2 | 9.37 E-2 |
| Ingestion[a] | 9.57 E-2 | 1.12 E+0 | 9.57 E-2 |
| Direct Exposure[b] | 2.29 E-2 | 2.29 E-2 | 2.29 E-2 |
| Total | 1.21 E-1 | 1.20 E+0 | 2.12 E-1 |
| 3. Post-Operational Phase[d] | | | |
| Inhalation | 8.05 E-2 | 2.50 E+0 | 6.77 E-1 |
| Ingestion[a] | 5.18 E-1 | 1.17 E+1 | 5.18 E-1 |
| Direct Exposure[b] | 2.91 E+0 | 2.91 E+0 | 2.91 E+0 |
| Total | 3.51 E+0 | 1.71 E+1 | 4.11 E+0 |

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[a] Includes vegetables, meat, and milk.

[b] Includes cloud and ground exposure.

[c] Does not consider dose commitments due to offsite rock drying.

[d] Calculated for conventional land and lakes reclamation. Exposures would be lower for proposed sand/clay cap reclamation as a result of lower terrestrial aquatic impacts (Tables V-1 and V-2).

[e] 6.89 E-2 = 6.89 x $10^{-2}$.

## Table V-4

## Radium-226, Uranium and Thorium Concentrations (in pCi/gram) in Florida Phosphate Mine Products and Wastes[a]

| Material | Radium-226 | Uranium | | | Thorium | | | | Uranium Series[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 234 | 235 | 238 | 227 | 228 | 230 | 232 | Total | Percent |
| Marketable Rock | 42 | 41 | 1.9 | 41 | 2.0 | 0.6 | 42.3 | 0.4 | 168.2 | 45 |
| Slimes | 45 | 42 | 2.6 | 44 | 2.3 | 1.2 | 48 | 1.4 | 181.6 | 49 |
| Sand Tailings | 7.5 | 5.2 | 0.4 | 5.3 | 2.2[c] | 0.9[c] | 4[d] | 0.9[d] | 22.4 | 6 |
| TOTAL | 94.5 | 88.2 | 4.9 | 90.3 | 4.3 | 1.8 | 94.3 | 2.7 | 372.2 | 100 |

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[a] Source: Guimond and Windham, 1975, except where noted otherwise.

[b] Total equals combined activity of uranium-234, 235, 238, radium-226, and thorium-230. Percentage shows percent of total uranium series activity in that material fraction, assuming equal weights of materials.

[c] Rough approximation calculated by averaging contents of marketable rock and slimes.

[d] Based on similarity with thorium-232 distribution, which appears to be an average even though it is a measured value. Source: Texas Instruments, Inc., 1978.

## Table V-5

## Radiological Characteristics of Unaltered Lands in Three Regions of Florida: Geometric Mean and Range

| Location | Radium-226 in Soil | | External Gamma Level[c] | Radon Flux |
|---|---|---|---|---|
| | Surface[a] | Core[b] | | |
| | pCi/g | pCi/g | µR/hr | pCi/m$^2$-s |
| Alachua County | 0.6<br>(0.3-2.1)<br>N=6 | 0.9<br>(0.3-4.7)<br>N=6 | 6<br>(5-8)<br>N=7 | 0.9<br>(0.2-3.2)<br>N=8 |
| Hamilton County | 0.4<br>(0.2-0.8)<br>N=3 | 1.3<br>(0.6-4.4)<br>N=3 | 4<br>---<br>N=1 | 0.1<br>---<br>N=1 |
| Polk County | 0.6<br>(0.1-3.8)<br>N=20 | 0.4<br>(0.2-3.1)<br>N=18 | 5<br>(4-7)<br>N=9 | 0.2<br>(<0.1-1.7)<br>N=17 |
| Combined Areas | 0.6<br>(0.1-3.8)<br>N=29 | 0.6<br>(0.2-4.7)<br>N=27 | 5<br>(4-8)<br>N=17 | 0.3<br>(<0.1-3.2)<br>N=26 |

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[a] Average to depth of 0.3 m.
[b] Averaged over the first 1.8 m depth.
[c] Mean value at one meter above ground.

Note: N = number of sites.

Source: Roessler and others, 1978a.

## Table V-6

## Rule-of-Thumb Predictors for Radon Flux

| Material | Flux-to-Radium Ratio[a] | |
|---|---|---|
| | Theoretical[b] | Measured[c] |
| High Flux Type | | |
| Unaltered Land | 0.53 | 0.53 |
| Debris | 0.52 | 0.58 |
| Average | 0.52 | 0.56 |
| Low Flux Type | | |
| Overburden | 0.34 | 0.27 |
| Tailings | 0.32 | 0.24 |
| Settled Clays | 0.20 | 0.22 |
| Average | 0.29 | 0.24 |

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[a] Flux in pCi/m$^2$-sec emanating from specified soil type containing 1 pCi/g of radium-226.

[b] Determined by inserting typical soil parameters into the infinite single layer theoretical flux model.

[c] Determined by taking ratio of observed geometric means of surface flux and radium-226 concentration for the respective land types.

Source: Roessler and others, 1978a.

Table V-7

Summary of the Radiological Baseline Monitoring Program

Page 1 of 2

| Medium | Locations[a] | Sample Type & Frequency | Analysis |
|---|---|---|---|
| I. Air | | | |
| 1. Particulates | 4,14,23 | Continuous sample collection for one week in each of two seasons. | Ra-226 |
| 2. Radon Concentration | 4,14,15 | Three continuous 48-hour samples for one week in each of two seasons. | Rn-222 |
| 3. Radon Flux | 15 | Two determinations in each of two seasons (each determination based on morning and afternoon samplings). | Rn-222 Flux |
| II. Terrestrial | | | |
| 1. Ambient Gamma Radiation[b] | 3,6,8, 11,14,21, 25 | Continuous monthly readings using thermoluminescent dosimeters. | Ambient Gamma |
| 2. Subsurface Radioactivity | 2,10,13, 16,26 | Composites of overburden, leach zone, and matrix from each boring. Sampled once. | Natural U and Ra-226 |
| 3. Vegetation | | | |
| a) Citrus Crops | 22,30,31, 32, 33 | Once at harvest. | Ra-226 |
| b) Pasture Grasses | 22,29,30, 31,32 | Once. | Ra-226 |
| III. Water | | | |
| 1. Surface Water[b] | 1,5,7,9, 12,17,18 19,20,26 | Monthly grab samples. | Monthly: Gross Alpha in suspended and dissolved solids. Quarterly: Ra-226 in dissolved soli |

Table V-7 (Continued)

Page 2 of 2

| Medium | Locations[a] | Sample Type & Frequency | Analysis |
|---|---|---|---|
| 2. Sediments | 4,7,19<br>26 | Once. | Ra-226 |
| 3. Ground Water | | | |
| a) Drinking Water | 22,23,24 | Once. | Ra-226 in dissolved solids. |
| b) Well Water | 3,6,24,26,<br>27,28,34 | Once. | Ra-226 in dissolved solids. |

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[a] Locations are shown in Figure V-1 and described in Table V-8

[b] Sampling and analysis performed by Environmental Sciences and Engineering, Inc.

Table V-8

Sampling Locations for the Radiological Baseline Program

Page 1 of 3

| Location | Sample Type | Description |
|---|---|---|
| 1 | Surface Water | Lettis Creek near property on section line in NW1/4, NW1/4, Sec 18, T34S, R23E |
| 2 | Soil Core | NW1/4, NW1/4, Sec 17, T34S, R24E |
| 3 | Direct Gamma and Well Water | W of Seaboard Coast Line R.R. at intersection of Vandolah Rd. and Fort Green-Ona Rd. in NE1/4, NE1/4, Sec 17, T34S, R24E (observation well MCSA-2) |
| 4 | Sediment | Property boundary at Oak Creek inflow and Vandolah Rd. at center of Sec 16, T34S, R24E |
|  | Air Particulates and Radon Concentration | Residence about 200 feet SW of Oak Creek and Vandolah Rd. |
| 5 | Surface Water | Troublesome Creek at Vandolah Rd. in NE1/4, Sec 14, T34S, R24E |
| 6 | Direct Gamma, and Well Water | NW1/4, Sec 22, T345, R23E (observation well MSCA-6) |
| 7 | Surface Water and Sediment | Brushy Creek inflow at section line in Sec 24, T345, R23 E |
| 8 | Direct Gamma | Near Oak Creek in SE1/4, Sec 20, T34S, R24E |
| 9 | Surface Water | Oak Creek at Seaboard Coast Line R.R. in NE1/4, NE1/4, Sec 20, T34S, Range 24E |
| 10 | Soil Core | E of Dink Albritton Rd. in center of Sec 22, T34S, R24E |
| 11 | Direct Gamma | Near property of end of Griffin-Whidden Rd. in SE1/4, Sec 23, T34S, R24E |
| 12 | Surface Water | Horse Creek at State Road 64 in SW1/4, SW1/4, Sec 28, T34S, R23E |
| 13 | Soil Core | NE1/4, Sec 28, T34S, R23E |
| 14 | Air Particulates, Radon Concentration, and Direct Gamma | Farm in SW1/4, Sec 27, T34S, R23E |

Table V-8 (Continued)

| Location | Sample Type | Description |
|---|---|---|
| 15 | Radon Concentration and Radon Flux | Center of Sec 25, T34S, R23E |
| 16 | Soil Core | Center of Sec 30, T34S, R24E |
| 17 | Surface Water | Property boundary at Hickory Creek outflow in SW1/4, NW1/4, Sec 26, T34S, R24E |
| 18 | Surface Water | Brushy Creek at State Road 64 in NW1/4, Sec 36, T34S, R23E |
| 19 | Surface Water and Sediment | Brushy Creek outflow at section line in SE1/4, Sec 36, T34S, R23E |
| 20 | Surface Water | Oak Creek at State Road 64 in NE1/4, Sec 32, T34S, R23E |
| 21 | Direct Gamma | N of State Road 64 on W side of Ona, Florida in NW1/4, Sec 33, T34S, R24E |
| 22 | Drinking Water | Residence in NW section of Ona, Florida (Well 04-08) |
|  | Pasture Vegetation | N of Third St. in NW section of Ona, Florida |
|  | Citrus Crop | NW of corner of Third St. and Oak St. in NW section of Ona, Florida |
| 23 | Air Particulates | Exxon station on State Road 64 in Ona, Florida |
|  | Drinking Water | Exxon station on State Road 64 (Well 53-01) |
| 24 | Drinking Water | Residence in SW section of Ona, Florida (Well 46-15) |
|  | Well Water | Adjacent to Ona,Florida in NW1/4, Sec 33, T34S, R24E (Observation well MSCA-14) |
| 25 | Direct Gamma | SW1/4, SW1/4, Sec 5, T35S, R24E |
| 26 | Surface Water, Sediment, Well Water, and Soil Core | Oak Creek outflow at property boundary in SE1/4, SW1/4, Sec 4, T35S, R24E (observation well MSCA-13) |

Table V-8 (Continued)

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| | | |
|---|---|---|
| 27 | Well Water | N of State Road 64 in SE1/4, Sec 27, T34S, R23E (observation well MSCA-8) |
| 28 | Well Water | SW1/4, SW1/4, Sec 31, T34S, R24E (observation well MSCA-9) |
| 29 | Pasture Vegetation | S of State Road 64 in NW 1/4, Sec. 32, T34S, R24E |
| 30 | Pasture Vegetation and Citrus Crop | N of McLeod Rd. in SW 1/4, Sec. 15, T34S, R23E |
| 31 | Pasture Vegetation and Citrus Crop | S of State Road 64 in NW 1/4, Sec. 35, T34S, R23E |
| 32 | Pasture Vegetation and Citrus Crop | S of Vandolah Rd. at intersection with Dink Arbritton Rd. in center of Sec. 15, T34S, R24E |
| 33 | Citrus Crop | NE 1/4, Sec. 26, T34S, R24E |
| 34 | Well Water | East of Dink Arbritton Rd. in center of Sec. 27, T34S, R24E (observation well MSCA-15). |

Table V-9

Page 1 of 2

## Correspondence of Sample Location Numbering Systems Used in Studies Conducted at the MCC Site

| Draft EIS | ADA/DRI[a] | ESE[b] |
|---|---|---|
| 1 | SG-4 | 12[c] |
| 2 | NCL[d] | NCL |
| 3 | MCSA-2 | 10[e] |
| 4 | SG-9 | NCL |
| 5 | SG-11 | 5[c] |
| 6 | MSCA-6 | 6[e] |
| 7 | SG-3 | 9[c] |
| 8 | NCL | 15[e] |
| 9 | SG-8 | 6[c] |
| 10 | NCL | NCL |
| 11 | NCL | 12[e] |
| 12 | SG-14 | 2[c] |
| 13 | NCL | NCL |
| 14 | NCL | 5[e] |
| 15 | NCL | NCL |
| 16 | NCL | NCL |
| 17 | SG-10 | 8[c] |
| 18 | SG-2 | 1[c] |
| 19 | SG-1 | 10[c] |
| 20 | SG-7 | 3[c] |
| 21 | NCL | 14[e] |
| 22 | Well 04-08 | NCL |
| 23 | Well 53-01 | NCL |
| 24 | Well 46-15 & MSCA-14 | NCL |
| 25 | NCL | 3[e] |
| 26 | SG-5 & MSCA-13 | 4[c] |
| 27 | MSCA-8 | NCL |
| 28 | MSCA-9 | NCL |

Table V-9 (Continued)

| Draft EIS | ADA/DRI[a] | ESE[b] |
|---|---|---|
| 29 | NCL | NCL |
| 30 | NCL | NCL |
| 31 | NCL | NCL |
| 32 | NCL | NCL |
| 33 | NCL | NCL |
| 34 | MSCA-15 | NCL |

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[a] Source: MCC, 1977.
[b] Source: Environmental Science and Engineering, Inc., 1977.
[c] Surface water monitoring location numbering system.
[d] No corresponding location.
[e] Ambient gamma radiation monitoring location numbering system.

## Table V-10

## The Uranium Decay Series

Page 1 of 2

| Isotope | Symbol | Historical Name | Half Life | Radiation | Energy (MeV)[a] |
|---|---|---|---|---|---|
| Uranium-238 | $_{92}U^{238}$ | Uranium I | $4.5\times10^{9}$ yr. | α | 4.18(77), 4.13(23) |
| Thorium-234 | $_{90}Th^{234}$ | Uranium $X_1$ | 24.1 day | β | 0.19(65), 0.10(35) |
| | | | | γ | 0.09(15), 0.06(7), 0.03(7) |
| Proctactinium-234 | $_{91}Pa^{234}$ | Uranium $X_2$ | 1.18 min. | β | 2.31(93), 1.45(6), 0.55(1) |
| | | | | γ | 1.01(2), 0.77(1), 0.04(3) |
| Uranium-234 | $_{92}U^{234}$ | Uranium II | $2.50\times10^{5}$ yr. | α | 4.77(72), 4.72(28), |
| | | | | γ | 0.05(28) |
| Thorium-230 | $_{90}Th^{230}$ | Ionium | $8.0\times10^{4}$ yr. | α | 4.68(76), 4.62(24) |
| Radium-226 | $_{88}Ra^{226}$ | Radium | 1622 yr. | α | 4.78(94), 4.59(6) |
| | | | | γ | 0.19(4) |
| Radon-222 | $_{86}Rn^{222}$ | Radon | 3.82 day | α | 5.48(100) |
| Polonium-218 | $_{84}Po^{218}$ | Radium A | 3.05 min. | α | 6.00(100) |
| Lead-214 | $_{82}Pb^{214}$ | Radium B | 26.8 min. | β | 1.03(6), 0.66(40), 0.46(50), 0.40(4) |
| | | | | γ | 0.35(44), 0.29(24), 0.24(11), 0.05(2) |
| Bismuth-214 | $_{83}Bi^{214}$ | Radium C | 19.7 min. | β | 3.18(15), 2.56(4), 1.79(8), 1.33(33), 1.03(22), 0.74(20) |

Table V-TO (Continued)

| Isotope | Symbol | Historical Name | Half Life | Radiation | Energy (MeV)[a] |
|---|---|---|---|---|---|
| Bismuth-214 | | | | γ | 2.43(2), 2.20(6),<br>2.12(1), 1.85(3)<br>1.76(19), 1.73(2)<br>1.51(3), 1.42(4),<br>1.38(7), 1.28(2),<br>1.24(7), 1.16(2),<br>1.12(20), 0.94(5),<br>0.81(2), 0.77(7),<br>0.61(45) |
| Polonium-214 | $_{84}Po^{214}$ | Radium C' | $160 \times 10^{-6}$ sec. | α | 7.68(100) |
| Lead-210 | $_{82}Pb^{210}$ | Radium D | 19.4 yr. | β | 0.06(17), 0.02(83) |
| | | | | γ | 0.05(14) |
| Bismuth-210 | $_{83}Bi^{210}$ | Radium E | 5.0 day | β | 1.16(100) |
| Polonium-210 | $_{84}Po^{210}$ | Radium F | 138.4 day | α | 5.30(100) |
| Lead-206 | $_{82}Pb^{206}$ | Radium G | Stable | | |

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[a] Numbers in parenthesis equal the percent abundance of that specific emission (e.g., 15% of the nuclear transformations of Th-234 result in the emission of a 0.09 MeV photon).

Source: Adams and Lowder, 1964.

## Table V-11

## The Thorium Decay Series

Page 1 of 2

| Isotope | Symbol | Historical Name | Half Life | Radiation | Energy (MeV)[a] |
|---|---|---|---|---|---|
| Thorium-232 | $_{90}Th^{232}$ | Thorium | $1.41 \times 10^{10}$ yr. | α | 4.01(76), 3.95(24) |
| | | | | γ | 0.06(24) |
| Radium-228 | $_{86}Ra^{228}$ | Mesothorium I | 6.7 yr. | β | 0.05(100) |
| Actinium-228 | $_{89}Ac^{228}$ | Mesothorium II | 6.13 hr. | β | 2.18(10), 1.85(9), 1.72(7),<br>1.72(7), 1.13(53),<br>0.64(8), 0.45(13) |
| | | | | γ | 1.64(13), 1.59(12),<br>1.10, 1.04,<br>0.97 (18), 0.91(25),<br>0.46(3), 0.41(2),<br>0.34(11), 0.23,<br>0.18(3), 0.13(6),<br>0.11, 0.10, 0.08 |
| Thorium-228 | $_{90}Th^{228}$ | Radiothorium | 1.91 yr. | α | 5.42(72), 5.34(28) |
| | | | | γ | 0.08(2) |
| Radium-224 | $_{88}Ra^{224}$ | Thorium X | 3.64 day | α | 5.68(95), 5.45(5) |
| | | | | γ | 0.24(5) |
| Radon-220 | $_{86}Rn^{220}$ | Thoron | 54.5 sec. | α | 6.28(99+) |
| Polonium-216 | $_{84}Po^{216}$ | Thorium A | 0.158 sec. | α | 6.78(100) |
| Lead-212 | $_{82}Pb^{212}$ | Thorium B | 10.64 hr. | β | 0.58(14), 0.34(80),<br>0.16(6) |
| | | | | γ | 0.30(5), 0.24(82),<br>0.18(1), 0.12(2) |

Table V-11 (Continued)

Page 2 of 2

| Isotope | Symbol | Historical Name | Half Life | Radiation | Energy (MeV)[a] |
|---|---|---|---|---|---|
| Bismuth-212 | ${}_{83}\mathrm{Bi}^{212}$ | Thorium C | 60.5 min. | α | 6.09(10), 6.04(25) |
| | | | | β | 2.25(56), 1.52(4), |
| | | | | γ | 0.74(1), 0.63(2)<br>0.04(1) with<br>2.20(2), 1.81(1),<br>1.61(3), 1.34(2),<br>1.04(2), 0.83(8),<br>0.73(10), with |
| Polonium-212 | ${}_{84}\mathrm{Po}^{212}$ | Thorium C' | $0.30 \times 10^{-6}$ sec. | α | 8.78(100) |
| Thalium-208 | ${}_{81}\mathrm{Tl}^{208}$ | Thorium C" | 3.1 min. | β | 2.37(2), 1.79(47),<br>1.52, 1.25 |
| | | | | γ | 2.62(100), 0.86(14),<br>0.76(2), 0.58(83),<br>0.51(25), 0.28(9),<br>0.25(2) |
| Lead-208 | ${}_{82}\mathrm{Pb}^{208}$ | Thorium D | Stable | | |

---

[a] Numbers in parenthesis equal the percent abundance of that specific emission (e.g., 24% of the nuclear transformations of Th-232 result in the emission of a 0.06 MeV photon).

Source: MCC, 1977.

## Table V-12

## Direct Gamma Radiation in Composite Soil Core Samples

| | Location 2 6/17/80 | | | Location 10 6/16/80 | | | Location 13 6/13/80 | | | Location 16 6/12/80 | | | Location 26 6/12/80 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Composite Interval(ft)[a] | Type Material[b] | μR/hr[c] | Composite Interval(ft) | Type Material | μR/hr | Composite Interval(ft) | Type Material | μR/hr | Composite Interval(ft) | Type Material | μR/hr | Composite Interval(ft) | Type Material | μR/hr |
| 0 - 1 | TS | 1.0 | 0 - 1 | TS | 1.0 | 0 - 1 | TS | 1.5 | 0 - 0.5 | TS | 1.0 | 0 - 1 | TS | 1.5 |
| 1 - 3 | OB | 1.0 | 1 - 2.5 | OB | 1.0 | 1 - 4 | OB | 1.0 | 0.5 - 2.5 | OB | 1.0 | 1 - 3 | OB | 1.5 |
| 3 - 4.5 | OB | 1.0 | 2.5 - 11 | OB | 1.5 | 4 - 17 | OB | 2.0 | 2.5 - 4 | OB | 1.5 | 3 - 4.5 | OB | 1.0 |
| 4.5 - 6 | OB | 2.0 | 11 - 24 | OB | 6.0 | 17 - 21 | OB | 2.0 | 4 - 6 | OB | 2.0 | 4.5 - 10 | OB | 1.5 |
| 6 - 16 | OB | 8.0 | 24 - 29 | OB | 2.0 | 21 - 27 | OB | 2.0 | 6 - 11 | OB | 5.0 | 10 - 12 | LZ | 5.0 |
| 16 - 17 | LZ | 5.0 | 29 - 29.5 | OBHP | 5.0 | 27 - 31 | LZ | 11.0 | 11 - 13.5 | LZ | 6.0 | 12 - 21.5 | M* | 6.5 |
| 17 - 23 | M* | 4.0 | 29.5 - 31 | LZ | 6.0 | 31 - 36 | M | 5.5 | 13.5 - 26.5 | M* | 4.0 | 21.5 - 31.5 | M* | 4.0 |
| 23 - 35.5 | M | 3.0 | 31 - 46 | M* | 4.0 | 36 - 42 | M | 2.0 | 26.5 - 46.5 | MW | 1.0 | 31.5 - 53 | MW | 3.0 |
| 35.5 - 51 | M | 3.0 | 46 - 62 | M* | 3.0 | 42 - 49 | M | 3.0 | 46.5 - 56 | M | 1.5 | 53 - 60 | M* | 3.5 |
| 51 - 58 | M | 2.0 | 62 - 72 | M* | 4.0 | 49 - 61 | M | 2.5 | 56 - 57.5 | d | d | | | |
| 58 - 68.5 | M | 2.0 | | | | 61 - 66.5 | M | 2.5 | 57.5 - 63 | M | 3.0 | | | |
| 68.5 - 87 | M | 2.0 | | | | 66.5 - 77 | M | 2.0 | | | | | | |
| 87 - 95 | M | 2.0 | | | | 77 - 88 | M | 2.0 | | | | | | |
| 95 - 105 | M | 2.0 | | | | 88 - 103 | M | 2.0 | | | | | | |

---

[a] Relative to ground surface.
[b] TS = Top Soil, OB = Overburden, HP = Hardpan, LZ = Leached Zone, M = Matrix (* indicates mineable), MW = Matrix Waste.
[c] Gross readings taken with Ra-226 calibrated Eberline PRM-7 inside lead shield. Shielded background = 1.0 μR/hr.
[d] Hard limey chert, discarded in the field.

Table V-13

## Analysis of Composite Soil Core Samples for Radium-226 and Natural Uranium

| Location | Date Drilled | Composite Interval(ft)[a] | Type of Material[b] | Activity (pCi/g dry)[c] Ra-226 | Activity (pCi/g dry)[c] Unat |
|---|---|---|---|---|---|
| 2 | 6/17/80 | 0-6 | OB | 0.60 ± 0.03 | 3.4 ± 0.2 |
| | | 6-16 | OB | 13.6 ± 0.7 | 6.7 ± 0.3 |
| | | 16-17 | LZ | 16.2 ± 0.8 | 63 ± 3 |
| | | 17-105 | M | 5.4 ± 0.3 | 14.6 ± 0.7 |
| 10 | 6/16/80 | 0-11 | OB | 0.32 ± 0.02 | 0.4 ± 0.2 |
| | | 11-24 | OB | 10.8 ± 0.5 | 40 ± 2 |
| | | 24-29.5 | OB | 2.1 ± 0.1 | 11.7 ± 0.6 |
| | | 29.5-31 | LZ | 13.1 ± 0.6 | 21 ± 1 |
| | | 31-72 | M | 5.6 ± 0.3 | 23 ± 1 |
| 13 | 6/13/80 | 0-27 | OB | 0.78 ± 0.04 | 3.9 ± 0.2 |
| | | 27-31 | LZ | 36 ± 2 | 88 ± 4 |
| | | 31-36 | M | 14.4 ± 0.7 | 32 ± 2 |
| | | 36-103 | M | 3.3 ± 0.2 | 5.7 ± 0.3 |
| 16 | 6/12/80 | 0-6 | OB | 1.43 ± 0.07 | 3.4 ± 0.8 |
| | | 6-13-5 | OB+LZ | 11.2 ± 0.6 | 22 ± 1 |
| | | 13.5-63 | M | 3.2 ± 0.2 | 7.7 ± 0.5 |
| 26 | 6/12/80 | 0-10 | OB | 0.41 ± 0.02 | 2.2 ± 0.4 |
| | | 10-12 | LZ | 11.6 ± 0.6 | 43 ± 2 |
| | | 12-60 | M | 10.3 ± 0.5 | 36 ± 2 |

---

[a] Relative to ground surface.
[b] OB = overburden, LZ = leached zone, M = matrix.
[c] One pCi of $U_{nat}$ = 0.4886 pCi U-238 + 0.4886 pCi U-234 + 0.0227 pCi U-235.

## Table V-14

## Radium-226 Concentrations in Topsoil, Overburden, Leached Zone, and Matrix of Mining Lands[a]

| Radium-226 Parameter vs. Material Type[b,c] | Radium-226 Parameter Values (pCi/g dry) | | |
|---|---|---|---|
| | North Florida | Central Florida | MCC Site |
| **Surface Soil (0-1 ft)** | | | |
| Geometric Mean | 0.4 | 0.5 | No data |
| Range of site means | (0.2-0.8) | (0.2-3.8) | |
| Range of individual samples | (0.2-0.8) | (0.2-3.8) | |
| Number of sites[c] | 3 | 5 | |
| **Upper Layer Overburden (0-6 ft)** | | | |
| Geometric Mean | 1.3 | 0.6 | 1.0 |
| Range of site means | (0.6-4.4) | (0.3-2.1) | -- |
| Range of individual samples | (0.6-10.6) | (0.2-3.8) | (0.6-1.43) |
| Number of sites | 3 | 6 | 2 |
| **Overburden (Surface to Top of Leached Zone)** | | | |
| Geometric Mean | | 1.6 | 1.5 |
| Range of site means | d | (0.5-7.2) | -- |
| Range of individual samples | | (0.2-7.2) | (0.32-13.6) |
| Number of sites | | 7 | 8 |
| **Leached Zone** | | | |
| Geometric Mean | | 9.4 | 17.3 |
| Range of site means | d | (2.0-45.6) | -- |
| Range of individual samples | | (1.2-45.6) | (11.6-36) |
| Number of sites | | 7 | 4 |
| **Overburden (Surface to Matrix)** | | | |
| Geometric Mean | 2.5 | 2.5 | 3.7 |
| Range of site means | (1.5-5.3) | (0.5-7.2) | -- |
| Range of individual samples | (0.6-10.6) | (0.2-30.6) | (0.32-36) |
| Number of sites | 3 | 8 | 12 |
| **Matrix** | | | |
| Geometric Mean | 10.9[e] | 25.9[e] | 5.5[f] |
| Range of site means | (5.1-31.6) | (13.2- 84.2) | -- |
| Range of individual samples | (2.6-58.8) | ( 6.0-136.5) | (3.2-14.4) |
| Number of sites | 6 | 13 | 6 |

---

[a] Source: Roessler and others, 1978b (north and central Florida values); Table V-13 (MCC site values).

[b] Mean of individual site sample means for the north and central Florida sites; mean of individual samples for MCC site.

[c] Number of sites = the number of individual samples for the MCC site.

[d] Leached zone not present in typical north Florida profile.

[e] Site means calculated from mixed matrix samples and from depth-weighted average of cores (This footnote taken directly from source).

[f] Depth-weighted average of all matrix cores.

## Table V-15

## Average Annual Doses to the General Public In the United States

| Source | mrem/yr | Percent of total |
|---|---|---|
| Natural Background | | 39 |
| Cosmic[a] | 28 | |
| Terrestrial | | |
| External[b] | 26 | |
| Internal[c] | 28 | |
| Total | 82 | |
| Man-Made Sources | | |
| Medical | | 56 |
| Medical Diagnostic x-ray[d] | 79 | |
| Fluoroscopic Examination[d] | 20.6 | |
| Dental Diagnostic x-ray[d] | 3.1 | |
| Radiopharmaceuticals[c] | 15.8 | |
| Total | 118.5 | |
| Others[e] | | 5 |
| Atmospheric Weapons Tests | 4.5 | |
| Nuclear Industry | 1.0 | |
| Consumer Products | 4.5 | |
| Miscellaneous | 0.5 | |
| Total | 10.5 | |
| Total | 211 | 100 |

---

[a] The actual value for cosmic radiation is about 31 mrem/yr. A 10 percent reduction factor is applied to account for people spending a large fraction of time indoors and structural shielding of the building providing protection.

[b] The actual value for terrestrial radiation is 44 mrem/yr. A 20 percent reduction factor is applied for structural shielding by buildings and an additional 20 percent reduction to account for shielding provided by outer tissues of the body is then applied to this value.

[c] Based on gonadal dose.

[d] Based on bone marrow dose.

[e] Based on whole body dose.

Source: BEIR, 1980 (typescript edition).

## Table V-16

### Monthly Ambient Gamma Radiation Levels (mrem/31 days) During the Period February 1976 Through January 1977

| Location | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Annual (mrem/365 days) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 0.9 | 0.8 | 3.3 | 2.7 | 3.1 | 2.8 | 2.5 | 2.8 | 3.3 | 3.3 | 3.1 | 3.2 | 31.2 |
| 6 | 1.9 | 1.3 | 3.2 | 2.6 | 2.5 | 2.7 | 2.3 | 2.7 | 3.4 | 3.3 | 3.1 | 3.0 | 31.4 |
| 8 | 1.0 | 0.7 | NR[a] | 2.9 | 2.8 | 2.9 | 2.3 | 2.6 | 3.3 | 3.1 | 3.0 | 2.9 | 29.4 |
| 11 | 1.0 | 1.4 | 3.1 | 2.8 | 2.8 | 2.8 | 3.1 | 3.0 | 3.2 | 3.5 | 3.7 | 3.0 | 33.1 |
| 14 | 0.9 | 1.0 | 3.0 | 2.9 | 3.4 | 2.8 | NR | 2.6 | 3.2 | 3.2 | 3.1 | 3.4 | 31.6 |
| 21 | 0.8 | 0.9 | 2.8 | 2.6 | 3.1 | 3.2 | 2.5 | 2.9 | 3.1 | 3.5 | 3.3 | 3.2 | 31.3 |
| 25 | 0.9 | 0.8 | 3.5 | 3.0 | 3.2 | 2.9 | 2.4 | 2.8 | 3.7 | 3.2 | 3.2 | 3.1 | 32.1 |
| A[b] | 0.8 | 1.1 | 2.7 | 2.8 | 2.7 | 2.7 | 2.1 | 2.4 | 3.2 | 3.1 | 3.3 | 3.1 | 29.4 |
| B[c] | 0.7 | 0.8 | 2.6 | 2.5 | 2.9 | 2.9 | 2.3 | 2.5 | 3.3 | 3.2 | 3.2 | 3.0 | 29.3 |
| C[d] | NR | 1.3 | 3.2 | 2.6 | 3.6 | 3.0 | 2.7 | 2.9 | 3.7 | 3.8 | 3.5 | 3.5 | 35.9 |

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[a] Not reported.
[b] Exact location unknown. Described as north of MCC property.
[c] Exact location unknown. Described as south of MCC property.
[d] Exact location unknown. Described as in Wauchula.

Source: Environmental Science and Engineering, Inc., 1977.

## Table V-17

## Analysis of Vegetation for Radium-226

| Type | | Location | Date Collected | Ra-226 (pCi/g dry) |
|---|---|---|---|---|
| Citrus Fruit | Lemon | 22 | 9/14/80 | 0.15 ± 0.01 |
| | Orange | 30 | 9/13/80 | 0.09 ± 0.01 |
| | Orange | 31 | 9/13/80 | 0.17 ± 0.01 |
| | Orange | 32 | 9/13/80 | 0.04 ± 0.01 |
| | Orange | 33 | 9/13/80 | 0.09 ± 0.01 |
| | Geometric Mean | | | 0.10 |
| Pasture Vegetation | Bahia, Pangola, Bermuda | 22 | 9/14/80 | <0.15[a] |
| | Bahia, Pangola, Bermuda | 29 | 9/13/80 | 0.27 ± 0.05 |
| | Bahia, Pangola, Bermuda | 30 | 9/13/80 | 0.14 ± 0.04 |
| | Bahia, Pangola, Bermuda | 31 | 9/13/80 | 0.30 ± 0.07 |
| | Bahia, Pangola, Bermuda | 32 | 9/13/80 | <0.15[a] |
| | Geometric Mean | | | 0.19 |

---

[a] Elevated sensitivity due to small sample size. Included in the mean.

Table V-18

Radon-222 Flux at Sampling Location No. 15

| Sample Date | Radon Flux ($pCi/m^2$-sec)[a] | | |
|---|---|---|---|
| | Morning | Afternoon | Average |
| "Wet" Season[b] | | | |
| 5/21/80 | 0.19 ± 0.03 | 0.06 ± 0.16 | 0.12 |
| 5/27/80 | 0.26 ± 0.61 | 0.39 ± 0.05 | 0.32 |
| 5/28/80 | 0.25 ± 0.03 | 0.20 ± 0.06 | 0.22 |
| Mean ± S.D.[c,d] | 0.26 ± 0.01 | 0.30 ± 0.13 | 0.28 |
| "Dry" Season[b] | | | |
| 10/21/80 | 0.48 ± 0.42 | 0.55 ± 0.06 | 0.52 |
| 10/23/80 | 0.60 ± 0.30 | 0.73 ± 0.04 | 0.66 |
| Mean ± S.D. | 0.54 ± 0.08 | 0.64 ± 0.13 | 0.59 |
| Overall Mean ± S.D.[e] | | | 0.37±0.21 |
| Geometric Mean | | | 0.30 |

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[a] Error based on linear regression analysis parameters, as described in Appendix V-A.

[b] "Wet" and "dry" seasons refer to periods during which monthly precipitation is greater than and lesser than, respectively, the average monthly precipitation.

[c] Since data for comparison of "wet" and "dry" seasons is best collected on consecutive days, data from 5/21/80 was excluded from the calculation of the mean.

[d] Mean ± standard deviation.

Table V-19

Ambient Air Radon-222 Concentrations in Florida[a]

| Location | Radon Concentration (pCi/l) | |
|---|---|---|
| | Morning | Afternoon |
| Bartow | 0.276 (171)[a] | 0.042 (157) |
| Orlando | 0.083 (317) | 0.019 (266) |
| Jacksonville | 0.052 (180) | 0.028 (172) |

---

[a] Numbers in parentheses indicate the number of samples.

Source: USEPA, 1979.

## TABLE V-20

### Ambient Radon-222 Concentration in Air

| "Wet" Season[a] | | | | "Dry" Season[a] | | | |
|---|---|---|---|---|---|---|---|
| Location | Collection[b] Midpoint | Rn-222 Concentration[c] (pCi/liter) | LLD[d] (pCi/liter) | Location | Collection[b] Midpoint | Rn-222 Concentration[c] (pCi/liter) | LLD[d] (pCi/liter) |
| #4 | 1032 5/29/80 | 0.04 ± 0.26 | 0.43 | #4 | 0928 10/21/80 | 0.50 ± 0.18 | 0.18 |
| | 0956 5/31/80 | 0.30 ± 0.26 | 0.41 | | 0956 10/23/80 | 0.43 ± 0.15 | 0.15 |
| | 0931 6/02/80 | 0.77 ± 0.22 | 0.37 | | 0905 10/25/80 | 0.38 ± 0.13 | 0.11 |
| | Mean ± S.D.[e] | 0.37 ± 0.37 | | | Mean ± S.D. | 0.44 ± 0.06 | |
| #14 | 1053 5/29/80 | 0.05 ± 0.22 | 0.35 | #14 | 1023 10/21/80 | 0.40 ± 0.17 | 0.20 |
| | 1058 5/31/80 | 0.09 ± 0.19 | 0.33 | | 1003 10/23/80 | 0.34 ± 0.15 | 0.16 |
| | 1050 6/02/80 | 0.26 ± 0.24 | 0.37 | | 0947 10/25/80 | 0.30 ± 0.13 | 0.14 |
| | Mean ± S.D. | 0.13 ± 0.11 | | | Mean ± S.D. | 0.35 ± 0.05 | |
| #15 | 1010 5/29/80 | 0.55 ± 0.22 | 0.30 | #15 | 0956 10/21/80 | 0.70 ± 0.22 | 0.20 |
| | 1034 5/31/80 | 0.25 ± 0.17 | 0.24 | | 0958 10/23/80 | 0.68 ± 0.17 | 0.17 |
| | 1029 6/02/80 | 0.24 ± 0.18 | 0.26 | | 0946 10/25/80 | 0.17 ± 0.30 | 0.13 |
| | Mean ± S.D. | 0.35 ± 0.18 | | | Mean ± S.D. | 0.52 ± 0.30 | |
| "Wet" Season Mean | | 0.28 ± 0.24 | 0.34 | "Dry" Season Mean | | 0.43 ± 0.17 | 0.16 |

---

[a] "Wet and "dry" seasons refer to periods during which monthly precipitation is greater than and lesser than, respectively, the average monthly precipitation.

[b] Midpoint of a continuous sampling period of approximately 48 hours duration.

[c] The error given is based on the net counting error at the 95% confidence level (2 sigma).

[d] Lower limits of detection (LLD's) are equal to 4.66 times the background counting error.

[e] Arithmetic mean ± standard deviation.

## Table V-21

## Analysis of Airborne Particulates for Radium-226

| Location | Collection Period | Volume ($m^3$) | Ra-226 ($fCi/m^3$)[b] |
|---|---|---|---|
| | "Wet" Season[a] | | |
| 4 | 5/30/80 - 6/07/80 | 487 | 0.12 ± 0.06 |
| 14 | 5/30/80 - 6/07/80 | 565 | 0.30 ± 0.05 |
| 23 | 5/23/80 - 6/07/80 | 470 | 0.38 ± 0.06 |
| | "Dry" Season[a] | | |
| 4 | 10/20/80 - 10/27/80 | 430 | 0.28 ± 0.07 |
| 14 | 10/20/80 - 10/27/80 | 477 | 0.13 ± 0.06 |
| 23 | 10/20/80 - 10/27/80 | 476 | 0.17 ± 0.06 |

---

[a] "Wet" and "dry" seasons refer to periods during which monthly precipitation is greater than and lesser than, respectively, the average monthly precipitation.

[b] fCi = $10^{-15}$ curies.

## Table V-22

## Ambient Air Particulate Radionuclide Concentrations in Polk County

| Decay Series | Radionuclide | Concentration ($fCi/m^3$)[b] | |
|---|---|---|---|
| | | Mean[a] | Std. Dev. |
| Uranium-238 | | | |
| | U-238 | 0.39 | 0.34 |
| | U-234 | 0.39 | 0.34 |
| | Th-230 | 0.42 | 0.11 |
| | Ra-226 | 0.48 | 0.45 |
| Uranium-235 | | | |
| | U-235 | 0.03 | 0.02 |
| | Th-227 | 0.05 | 0.02 |
| Thorium-232 | | | |
| | Th-232 | 0.04 | 0.01 |
| | Th-228 | 0.15 | 0.04 |

---

[a] Six stations with two samples at each of approximately 5000 $m^3$.

[b] fCi = $10^{-15}$ curies.

Source: USEPA, 1979.

## Table V-23

### Analysis of Surface Water for Gross Alpha in Suspended and Dissolved Solids and for Radium-226 in Dissolved Solids

Page 1 of 3

| Location No. | 1 | | | 7 | | | 18 | | | 19 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Description | Lettis Creek (off-site) | | | Brushy Creek (inflow) | | | Brushy Creek (on-site) | | | Brushy Creek (outflow) | | |
| | Gross Alpha (pCi/l) | | Ra-226 | Gross Alpha (pCi/l) | | Ra-226 | Gross Alpha (pCi/l) | | Ra-226 | Gross Alpha (pCi/l) | | Ra-226 |
| Collection Date | Suspended | Dissolved | (pCi/l) | Suspended | Dissolved | (pCi/l) | Suspended | Dissolved | (pCi/l) | Suspended | Dissolved | (pCi/l) |
| Dec. 1975 | <1.0 | 2.5 | NA[a] | <0.5 | 2.3 | NA | <0.6 | 0.9 | NA | 2.2 | 1.5 | NA |
| Jan. 1976 | <0.5 | <0.6 | NA | 2.3 | 1.5 | NA | <0.4 | 2.0 | NA | <0.8 | 2.3 | NA |
| Feb. 1976 | NS[b] | NS | NS | <0.9 | <0.8 | <0.8 | <0.8 | <0.8 | 0.9 | <0.8 | <0.8 | <1.6 |
| Mar. 1976 | NS | NS | NS | <0.7 | 0.9 | NA | <0.7 | <1.3 | NA | <0.7 | 1.0 | NA |
| Apr. 1976 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| May 1976 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| June 1976 | <0.9 | <0.6 | 0.3 | NS | NS | NS | 1.5 | 1.4 | 1.0 | 0.9 | <1.3 | 1.3 |
| July 1976 | 4.5 | <1.3 | 0.6 | <1.0 | 1.9 | <0.4 | 2.1 | <1.0 | <0.4 | 4.0 | <1.0 | 0.3 |
| Aug. 1976 | <1.0 | <3.0 | 0.5 | <1.8 | <1.8 | 0.5 | <1.0 | <4.0 | 0.3 | <0.3 | 3.2 | 0.4 |
| Sept. 1976 | <0.9 | <2.6 | <0.2 | <0.9 | 7.1 | <0.3 | <0.9 | 6.3 | <0.3 | 0.9 | 2.8 | <0.2 |
| Oct. 1976 | 1.3 | <1.3 | <0.2 | NS | NS | NS | <0.3 | <0.3 | <0.3 | <0.2 | 1.4 | <0.2 |
| Nov. 1976 | 2.4 | 2.3 | 0.9 | NS | NS | NS | <1.5 | <1.1 | 1.2 | 2.4 | 2.7 | 0.7 |
| Dec. 1976 | NS | NS | NS | NS | NS | NS | NA | NA | 0.3 | NA | NA | 0.4 |
| Jan. 1977 | NA | NA | 0.3 | NA | NA | 0.6 | NA | NA | 1.7 | NA | NA | 0.2 |
| Mar. 1977 | NA | NA | 0.2 | NA | NA | 0.2 | NA | NA | <0.1 | NA | NA | 0.4 |
| Geometric Mean[c] | 1.2 | 1.5 | 0.3 | 1.0 | 1.8 | 0.4 | 0.8 | 1.4 | 0.5 | 0.9 | 1.6 | 0.4 |

Table V-23 (Continued)

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Analysis of Surface Water for Gross Alpha in Suspended and Dissolved Solids and for Radium-226 in Dissolved Solids$^a$

| Location No. | 9 | | | 20 | | | 26 | | | 17 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Description | Oak Creek (on-site) | | | Oak Creek (on-site) | | | Oak Creek (outflow) | | | Hickory Creek (outflow) | | |
| Collection Date | Gross Alpha (pCi/l) Suspended | Gross Alpha (pCi/l) Dissolved | Ra-226 (pCi/l) | Gross Alpha (pCi/l) Suspended | Gross Alpha (pCi/l) Dissolved | Ra-226 (pCi/l) | Gross Alpha (pCi/l) Suspended | Gross Alpha (pCi/l) Dissolved | Ra-226 (pCi/l) | Gross Alpha (pCi/l) Suspended | Gross Alpha (pCi/l) Dissolved | Ra-226 (pCi/l) |
| Dec. 1975 | 1.3 | <0.5 | NA | <1.0 | <0.5 | NA | <0.5 | <1.0 | NA | NS | NS | NS |
| Jan. 1976 | <0.8 | <0.6 | NA | 1.4 | <0.9 | NA | 1.4 | 1.4 | NA | NS | NS | NS |
| Feb. 1976 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Mar. 1976 | NS | NS | NS | <1.5 | 0.7 | NA | NS | NS | NS | NS | NS | NS |
| Apr. 1976 | NS | NS | NS | <0.7 | <1.4 | 0.3 | <0.7 | <0.6 | 1.2 | NS | NS | NS |
| May 1976 | NS | NS | NS | NS | NS | NS | <0.3 | <0.5 | 0.4 | NR$^d$ | <0.3 | 0.4 |
| June 1976 | NS | NS | NS | <0.3 | 0.6 | 0.8 | 0.9 | 2.2 | 0.9 | <0.9 | 1.1 | 0.3 |
| July 1976 | <1.0 | <1.3 | 0.5 | <1.0 | <1.0 | <0.3 | <1.0 | <1.0 | <0.3 | <1.8 | <1.0 | 0.9 |
| Aug. 1976 | 1.5 | <1.7 | 0.6 | <1.8 | <0.3 | 0.5 | <0.3 | 2.5 | <0.2 | <1.0 | <1.8 | 0.8 |
| Sept.1976 | NS | NS | NS | <0.9 | <2.5 | 0.8 | <0.9 | <2.4 | <0.2 | NS | NS | NS |
| Oct. 1976 | NS | NS | NS | NS | NS | NS | 1.3 | 1.5 | <0.2 | 0.9 | <0.6 | <0.3 |
| Nov. 1976 | NS | NS | NS | NS | NS | NS | 4.4 | <1.1 | 1.3 | <0.6 | 0.9 | <0.2 |
| Dec. 1976 | NS | NS | NS | NS | NS | NS | NA | NA | 0.3 | NS | NS | NS |
| Jan. 1977 | NS | NS | NS | NA | NA | 0.2 | NA | NA | <0.2 | NA | NA | 0.3 |
| Mar. 1977 | NS | NS | NS | NS | NS | NS | NA | NA | 0.1 | NA | NA | 0.1 |
| Geometric Mean$^c$ | 1.1 | 0.9 | 0.5 | 1.0 | 0.8 | 0.4 | 0.9 | 1.2 | 0.3 | 1.0 | 0.6 | 0.3 |

Table V-23 (Continued)

| Location No. | 5 | | | 12 | | |
|---|---|---|---|---|---|---|
| Description | Troublesome Creek (off-site) | | | Horse Creek (off-site) | | |
| Collection Date | Gross Alpha (pCi/l) Suspended | Gross Alpha (pCi/l) Dissolved | Ra-226 (pCi/l) | Gross Alpha (pCi/l) Suspended | Gross Alpha (pCi/l) Dissolved | Ra-226 (pCi/l) |
| Dec. 1975 | <0.5 | <0.6 | NA | <0.8 | <0.5 | NA |
| Jan. 1976 | 1.9 | 1.1 | NA | <0.4 | <0.4 | NA |
| Feb. 1976 | 0.8 | 0.9 | 1.1 | <0.8 | 1.0 | 1.4 |
| Mar. 1976 | NS | NS | NS | <0.7 | 0.7 | NA |
| Apr. 1976 | NS | NS | NS | <0.7 | <0.6 | 0.4 |
| May 1976 | NR | 0.7 | 0.4 | 1.6 | <1.0 | 1.7 |
| June 1976 | <0.3 | NR | 3.4 | <0.6 | 3.8 | 0.5 |
| July 1976 | <1.0 | <1.0 | 0.5 | 0.4 | <1.3 | <0.3 |
| Aug. 1976 | <1.8 | 1.4 | 0.5 | 5.1 | <1.7 | <0.1 |
| Sept. 1976 | NS | NS | NS | 0.9 | <2.6 | <0.3 |
| Oct. 1976 | NS | NS | NS | 1.3 | 0.8 | <0.2 |
| Nov. 1976 | NS | NS | NS | 1.6 | <1.1 | 1.2 |
| Dec. 1976 | NA | NA | 0.7 | NA | NA | 0.5 |
| Jan. 1977 | NA | NA | 0.3 | NA | NA | 0.9 |
| Mar. 1977 | NA | NA | 0.2 | NA | NA | 0.1 |
| Geometric Mean[c] | 0.9 | 0.9 | 0.6 | 0.9 | 1.0 | 0.4 |

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[a] Not analyzed.
[b] Not sampled.
[c] Includes "less than" values.
[d] Not reported.

Source: Environmental Science and Engineering, Inc., 1977.

## Table V-24

## Typical Concentrations of Radium-226 in Surface Waters

| Type | Location | Radium-226 pCi/liter |
|---|---|---|
| Mississippi River | St. Louis, Mo. | 1.2-2.9 |
| Great Salt Lake | Utah | 5 |
| Curie Spring | Boulder, Col. | 267,000 |
| Ohio River | Pennsylvania | 0.6 |
| Surface Water Supply | Chicago, Ill. | 0.03 |
| Lithia Springs | Lithia, Fla. | 0.68 |
| Alafia River | Lithia, Fla. | 0.06 |
| Peace River | Ft. Meade, Fla. | 0.12 |
| Proposed Four Corners Mine Site | Hillsborough and Manatee Cos., Fla. | 0.18 |
| Osceloa National Forest | Columbia Co., Fl. | 0.07 |
| Peace River Basin | Hillsborough, Polk, Manatee and Hardee Cos., Fla. | 0.94 |
| Lake Manatee | Discharge at Sullivans Bridge | 0.32 |
| Manatee and Myakka Rivers | (S12, 525, T34S, R21E)<br>(S15, T35S, R22E) | 0.1 |
| Hookers Prairie | Bradly Junction, Fla. | 0.8 |

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Source: USEPA, 1979.

## Table V-25

## Analysis of Stream Sediments for Radium-226

| Location | Description | Date Collected | Ra-226 (pCi/g dry) |
|---|---|---|---|
| 7 | Brushy Creek, Inflow | 10/03/80 | 0.18 ± 0.03 |
| 19 | Brushy Creek, Outflow | 10/05/80 | 0.36 ± 0.05 |
| 4 | Oak Creek, Inflow | 10/05/80 | 0.20 ± 0.03 |
| 26 | Oak Creek, Outflow | 10/05/80 | 0.25 ± 0.04 |

Table V-26

Dissolved Radium-226 Activity (pCi/liter) in Central Florida Ground Water

| Areas Sampled | Surficial Aquifer | Floridan Aquifer | |
|---|---|---|---|
| | | Upper | Lower |
| I. MINERALIZED AREAS | | | |
| Unmined | | | |
| Geometric Mean | 0.22 | 2.76 | 1.81 |
| Range | 0.05-22.0 | 0.18-10.6 | 0.06-15.3 |
| Mined | | | |
| Geometric Mean | 0.83 | 1.61 | 3.06 |
| Range | 0.20-5.3 | 0.16-6.0 | 0.13-14.0 |
| II. Non-Mineralized Areas | | | |
| Geometric Mean | No Data | 5.1 | 1.53 |
| Range | | 0.20-7.9 | 0.23-14.7 |

---

Source: Kaufmann and Bliss, 1977.

## Table V-27

## Analysis of Ground Water Samples Collected During Aquifer Testing Program for Radium-226 in Dissolved Solids

| Aquifer | Well No. | Geologic Unit | Date Collected | Ra-226 (pCi/liter) |
|---|---|---|---|---|
| Surficial | MCRW-1 | Surficial Deposits | 3/11/80 | 1.80 ± 0.04 |
| | MCSA-9 | Surficial Deposits | 7/07/80 | 0.91 ± 0.14 |
| | MCSA-14 | Surficial Deposits | 7/12/80 | 4.55 ± 0.34 |
| | MCSA-15 | Surficial Deposits | 7/07/80 | 7.29 ± 0.43 |
| | MCSA-16 | Surficial Deposits | 7/06/80 | 4.89 ± 0.35 |
| | MCSA-7 | Surficial Deposits | 7/06/80 | 4.05 ± 0.32 |
| | Surficial Aquifer Geometric Mean Value | | | 3.2 |
| Upper Floridan | MCLF-1 | Hawthorn-Tampa Limestone | 1/08/80 | 7.05 ± 0.10 |
| Lower Floridan | MCLF-1 | Suwanee Limestone | 2/14/76 | 1.40 ± 0.02 |
| | MCLF-1 | Ocala Limestone | 3/08/76 | 1.11 ± 0.05 |
| | MCLF-1 | Ocala-Avon Park Limestone | 4/05/76 | 1.80 ± 0.04 |

Source: P.E. LaMoreaux and Associates, Inc., 1976.

## Table V-28

## Analysis of Ground Water for Dissolved Radium-226

| Location Number | Well Number[a] | Date Collected | Ra-226 (pCi/liter) |
|---|---|---|---|
| **Drinking Water** | | | |
| 23 | 53-01 | 10/05/80 | 2.0 ± 0.3 |
| 24 | 46-15 | 10/05/80 | 0.2 ± 0.1 |
| 22 | 04-08 | 10/05/80 | 0.1 ± 0.1 |
| **Well Water** | | | |
| 3 | MSCA-2 | 10/03/80 | 7.1 ± 1.1 |
| 6 | MSCA-6 | 10/05/80 | 0.4 ± 0.1 |
| 24 | MSCA-14 | 10/03/80 | 1.7 ± 0.3 |
| 26 | MSCA-13 | 10/05/80 | 0.5 ± 0.1 |
| 27 | MSCA-8 | 10/05/80 | 33.0 ± 4.9 |
| 28 | MSCA-9 | 10/05/80 | 0.6 ± 0.1 |
| 34 | MSCA-15 | 10/03/80 | 0.7 ± 0.1 |
| Well water geometric mean | | | 1.7 |

---

[a] Well numbers correspond to those reported in MCC (1977). All wells tap only the surficial aquifer.

## TABLE V-29

## ESTIMATED RADIOACTIVITY OF SITE MATERIALS, pCi/g

### Conventional Waste Disposal with Land-and-Lakes Reclamation

| Material | Ra-226 | U-238 | Th-230[a] | Pb-210[b] |
|---|---|---|---|---|
| **Baseline Conditions** | | | | |
| Overburden (0-6 ft) | 1.0[c] | 1.7[c] | 1.7 | 1.0 |
| Overburden (including leached zone) | 6.2[c] | 7.1[c] | 7.1 | 6.2 |
| Matrix | 5.5[c] | 7.9[c] | 7.9 | 5.5 |
| **Mine Products and Wastes[d]** | | | | |
| Product | 15.6 | 21.3 | 21.3 | 15.6 |
| Slimes | 5.1 | 8.1 | 8.1 | 5.1 |
| Sand tailings | 0.8 | 1.1 | 1.1 | 0.8 |
| **Reclaimed Wastes[e]** | | | | |
| Slimes | 5.8 | 7.4 | 7.4 | 5.8 |
| Tailings | 4.4 | 5.1 | 5.1 | 4.4 |

---

[a] Based on equilibrium with U-238 (Guimond and Windham, 1975).

[b] Based on equilibrium with Ra-226 (Partridge and others, 1978).

[c] Depth-weighted arithmetic averages of results given in Table V-13.

[d] Based on activity distribution given in Table V B-2.

[e] Capped with four feet of overburden. Activities are averaged over the upper six feet of material.

## TABLE V-30

## AMBIENT GAMMA RADIATION LEVELS ON RECLAIMED LANDS

### Conventional Waste Disposal with Land-and-Lakes Reclamation

| Land Type | Gamma Radiation (μR/hr) | | | |
|---|---|---|---|---|
| | Estimated Terrestrial Component | Cosmic Component | Total | Estimated TLD Reading |
| Undisturbed overburden | 1.8 | 3.5 | 5.3 | 3.4 |
| Reclaimed tailings | 7.9 | 3.5 | 11.4 | 9.5 |
| Reclaimed slimes | 10.4 | 3.5 | 13.9 | 12.0 |
| Site Average | 6.1 | -- | 9.0 | 7.4 |

## TABLE V-31

## RADON FLUXES (pCi/$m^2$-sec) OF PRODUCT AND SURFICIAL MATERIALS

### Conventional Waste Disposal with Land-and-Lakes Reclamation

| Material Type | Radon Flux | Comments |
|---|---|---|
| Product | 24.8 | From Equation B-2. |
| Undisturbed overburden | 0.37 | Average of 10 measurements (Section 2.6.1). |
| | 0.53 | Estimated from measured soil Ra-226 (Section 2.4.2) and Roessler's predictors (Table V-6). |
| Reclaimed slimes | 1.58 | From estimated Ra-226 activity (Table V-29) and Roessler's predictors. |
| Reclaimed tailings | 1.19 | From estimated Ra-226 activity and Roessler's predictors. |

## TABLE V-32

## ESTIMATED INDOOR WORKING LEVELS IN SLAB ON-GRADE STRUCTURES ON THE RECLAIMED MCC PROPERTY

### Conventional Waste Disposal With Land-and-Lakes Reclamation

| Land Type | Estimated WL[a] | Range of WL Measured in Polk County[b] |
|---|---|---|
| Undisturbed overburden | 0.0057 | 0.001-0.032 |
| Reclaimed slimes | 0.017 | 0.004-0.035 |
| Reclaimed tailings | 0.014 | 0.02-0.025 |

---

[a] Not including background (0.009 WL).

[b] Roessler, 1978a. Higher values have been reported (FDHRS, 1978).

# TABLE V-33

## SUMMARY OF RADIOLOGICAL AIR QUALITY PARAMETERS FOR THE OPERATIONAL PHASE WITH ROCK DRYER

| Site Boundary Receptors | Distance (km) | Ra-226 ($pCi/m^3$) | Rn-222 ($pCi/m^3$) | WL[b] | Ground Ra-226 Concentration ($pCi/m^2$) | Annual Dose Commitment[a] (mrem/yr) |
|---|---|---|---|---|---|---|
| N | 1.43 | 2.81 E-5[c] | 1.95 E-1 | 3.94 E-7 | 1.43 E+2 | 3.91 E-1 |
| NNE | 1.55 | 1.67 E-5 | 1.17 E-1 | 2.27 E-7 | 8.65 E+1 | 2.32 E-1 |
| NE | 2.02 | 1.08 E-5 | 7.11 E-2 | 1.86 E-7 | 5.74 E+1 | 1.49 E-1 |
| ENE | 2.64 | 9.81 E-6 | 6.11 E-2 | 2.03 E-7 | 5.62 E+1 | 1.35 E-1 |
| E | 4.26 | 9.48 E-6 | 6.04 E-2 | 2.50 E-7 | 5.24 E+1 | 1.31 E-1 |
| ESE | 4.63 | 5.54 E-6 | 3.47 E-2 | 1.80 E-7 | 3.39 E+1 | 7.53 E-2 |
| SE | 2.07 | 2.38 E-5 | 9.98 E-2 | 2.65 E-7 | 2.16 E+2 | 2.99 E-1 |
| SSE | 4.65 | 6.57 E-6 | 4.23 E-2 | 2.25 E-7 | 3.76 E+1 | 8.98 E-2 |
| S | 6.17 | 5.71 E-6 | 3.77 E-2 | 2.30 E-7 | 3.20 E+1 | 7.81 E-2 |
| SSW | 4.65 | 1.25 E-5 | 4.95 E-2 | 2.71 E-7 | 1.25 E+2 | 1.57 E-1 |
| SW | 6.24 | 7.49 E-6 | 4.89 E-2 | 3.10 E-7 | 4.28 E+1 | 1.01 E-1 |
| WSW | 7.06 | 1.08 E-5 | 7.17 E-2 | 5.00 E-7 | 6.63 E+1 | 1.46 E-1 |
| W | 7.85 | 1.28 E-5 | 9.67 E-2 | 6.99 E-7 | 7.00 E+1 | 1.77 E-1 |
| WNW | 3.23 | 2.00 E-5 | 1.34 E-1 | 6.30 E-7 | 1.03 E+2 | 2.78 E-1 |
| NW | 3.05 | 1.48 E-5 | 9.89 E-2 | 4.30 E-7 | 7.63 E+1 | 2.06 E-1 |
| NNW | 2.44 | 1.65 E-5 | 1.08 E-1 | 3.67 E-7 | 8.45 E+1 | 2.29 E-1 |
| Ona | 2.74 | 1.42 E-5 | 9.24 E-2 | 3.25 E-7 | 8.00 E+1 | 1.95 E-1 |

---

[a] As average lung dose to an adult.

[b] WL = working level, any combination of airborne short-lived radon daughters which, on complete decay, yield an alpha energy of $1.3 \times 10^5$ MeV/liter.

[c] 2.81 E-5 = $2.81 \times 10^{-5}$.

## TABLE V-34

### SUMMARY OF RADIOLOGICAL AIR QUALITY PARAMETERS FOR THE OPERATIONAL PHASE WITHOUT ROCK DRYER

| Site Boundary Receptors | Distance (km) | Ra-226 (pCi/m$^3$) | Rn-222 (pCi/m$^3$) | WL[b] | Ground Ra-226 Concentration (pCi/m$^2$) | Annual Dose Commitment[a] (mrem/yr) |
|---|---|---|---|---|---|---|
| N | 1.43 | 4.78 E-7[c] | 0[d] | 0[d] | 6.86 E+0 | 5.00 E-3 |
| NNE | 1.55 | 4.73 E-7 | 0 | 0 | 6.66 E+0 | 4.93 E-3 |
| NE | 2.02 | 4.83 E-7 | 0 | 0 | 6.79 E+0 | 5.04 E-3 |
| ENE | 2.64 | 7.60 E-7 | 0 | 0 | 1.17 E+1 | 8.03 E-3 |
| E | 4.26 | 5.03 E-7 | 0 | 0 | 8.29 E+0 | 5.37 E-3 |
| ESE | 4.63 | 6.44 E-7 | 0 | 0 | 9.85 E+0 | 6.80 E-3 |
| SE | 2.07 | 9.89 E-6 | 0 | 0 | 1.48 E+2 | 1.04 E-1 |
| SSE | 4.65 | 5.77 E-7 | 0 | 0 | 8.12 E+0 | 6.01 E-3 |
| S | 6.17 | 5.10 E-7 | 0 | 0 | 6.43 E+0 | 5.23 E-3 |
| SSW | 4.65 | 5.52 E-6 | 0 | 0 | 9.02 E+1 | 5.88 E-2 |
| SW | 6.24 | 8.96 E-7 | 0 | 0 | 1.04 E+1 | 9.10 E-3 |
| WSW | 7.06 | 1.57 E-6 | 0 | 0 | 2.09 E+1 | 1.62 E-2 |
| W | 7.85 | 9.15 E-7 | 0 | 0 | 1.14 E+1 | 9.38 E-3 |
| WNW | 3.23 | 5.83 E-7 | 0 | 0 | 7.48 E+0 | 6.00 E-3 |
| NW | 3.05 | 4.39 E-7 | 0 | 0 | 5.59 E+0 | 4.51 E-3 |
| NNW | 2.44 | 4.13 E-7 | 0 | 0 | 5.51 E+0 | 4.27 E-3 |
| Ona | 2.74 | 1.12 E-6 | 0 | 0 | 1.56 E+1 | 1.16 E-2 |

---

[a] As average lung dose to an adult.

[b] WL = working level, any combination of airborne short-lived radon daughters which, on complete decay, yield an alpha energy of $1.3 \times 10^5$ MeV/liter.

[c] 4.78 E-7 = $4.78 \times 10^{-7}$.

[d] Only particulate emissions are considered during the operational phase when the rock dryer is absent.

## TABLE V-35

## SUMMARY OF RADIOLOGICAL AIR QUALITY PARAMETERS FOR THE POST-OPERATIONAL PHASE

### Conventional Waste Disposal with Land-and-Lakes Reclamation

| Site Boundary Receptors | Distance (km) | Ra-226 ($pCi/m^3$) | Rn-222 ($pCi/m^3$) | WL[b] | Ground Ra-226 Concentration ($pCi/m^2$) | Annual Dose Commitment[a] (mrem/yr) |
|---|---|---|---|---|---|---|
| N | 1.43 | 0[c] | 3.93 E+0[d] | 1.99 E-5 | 0[c] | 1.67 E-2 |
| NNE | 1.55 | 0 | 4.02 E+0 | 1.96 E-5 | 0 | 1.61 E-2 |
| NE | 2.02 | 0 | 4.18 E+0 | 1.87 E-5 | 0 | 1.45 E-2 |
| ENE | 2.64 | 0 | 6.07 E+0 | 2.22 E-5 | 0 | 1.55 E-2 |
| E | 4.26 | 0 | 3.48 E+0 | 1.34 E-5 | 0 | 9.96 E-3 |
| ESE | 4.63 | 0 | 4.65 E+0 | 1.85 E-5 | 0 | 1.38 E-2 |
| SE | 2.07 | 0 | 5.75 E+1 | 1.06 E-4 | 0 | 4.47 E-2 |
| SSE | 4.65 | 0 | 3.64 E+0 | 1.99 E-5 | 0 | 1.74 E-2 |
| S | 6.17 | 0 | 2.47 E+0 | 1.60 E-5 | 0 | 1.52 E-2 |
| SSW | 4.65 | 0 | 5.23 E+0 | 2.81 E-5 | 0 | 2.43 E-2 |
| SW | 6.24 | 0 | 4.64 E+0 | 2.85 E-5 | 0 | 2.64 E-2 |
| WSW | 7.06 | 0 | 1.06 E+1 | 4.90 E-5 | 0 | 4.11 E-2 |
| W | 7.85 | 0 | 7.48 E+0 | 4.21 E-5 | 0 | 3.82 E-2 |
| WNW | 3.23 | 0 | 4.88 E+0 | 2.73 E-5 | 0 | 2.42 E-2 |
| NW | 3.05 | 0 | 3.82 E+0 | 2.23 E-5 | 0 | 2.02 E-2 |
| NNW | 2.44 | 0 | 3.47 E+0 | 1.97 E-5 | 0 | 1.76 E-2 |
| Ona | 2.74 | 0 | 7.87 E+0 | 3.38 E-5 | 0 | 2.56 E-2 |

---

[a] As average lung dose to an adult.

[b] WL = working level, any combination of airborne short-lived radon daughters which, on complete decay, yield an alpha energy of $1.3 \times 10^5$ MeV/liter.

[c] Only radon emissions are considered during the post-operational phase.

[d] 3.93 E+0 = $3.93 \times 10^0$.

## TABLE V-36

## SUMMARY OF RADIOLOGICAL PARAMETERS
## SAND/CLAY MIX CAP RECLAMATION PLAN (PROPOSED)

| Reclaimed Land Type | Ra-226 Concentration in upper six feet (pCi/g) | Total Gamma Exposure Rate[a] (μR/hr) | Radon Flux (pCi/m$^2$-sec) | Indoor Working Level[b] (WL) |
|---|---|---|---|---|
| Undisturbed Overburden | 1.0 | 5.3 (1.8) | 0.53 | 0.0057 |
| Capped, slimes[c] | 2.6 | 8.2 (4.7) | 0.70 | 0.0097 |
| Covered slimes[d] | 4.9 | 12.3 (8.8) | 1.32 | 0.015 |
| Covered tailings[d] | 1.3 | 5.8 (2.3) | 0.35 | 0.0060 |
| Site Average | 2.8 | 8.5 (5.0) | 0.82 | 0.010 |

---

[a] External terrestrial contribution given in parentheses.
[b] Does not include background.
[c] Four foot-thick sand/clay cap (SCR = 8/1).
[d] One foot-thick overburden cover.

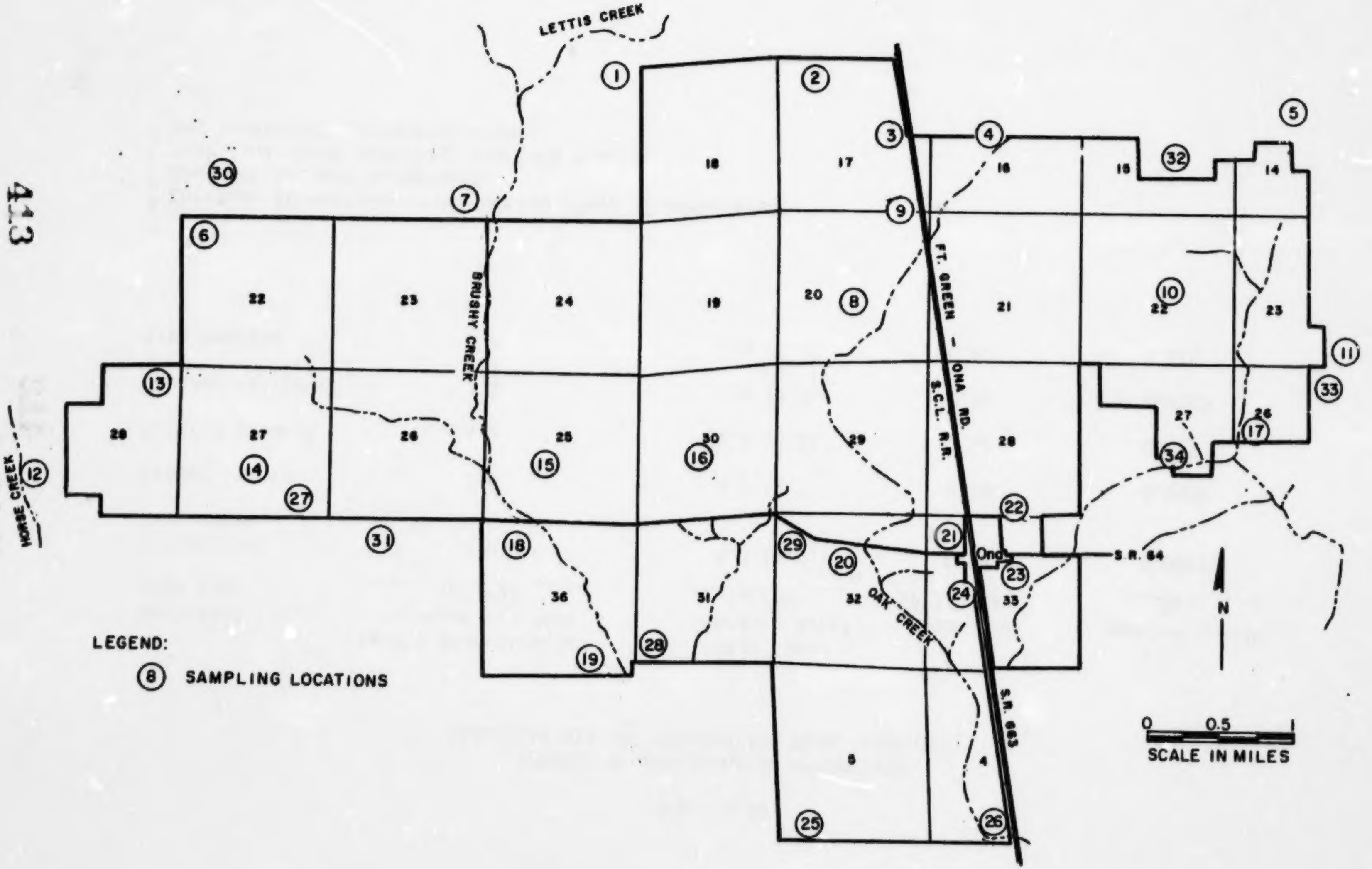
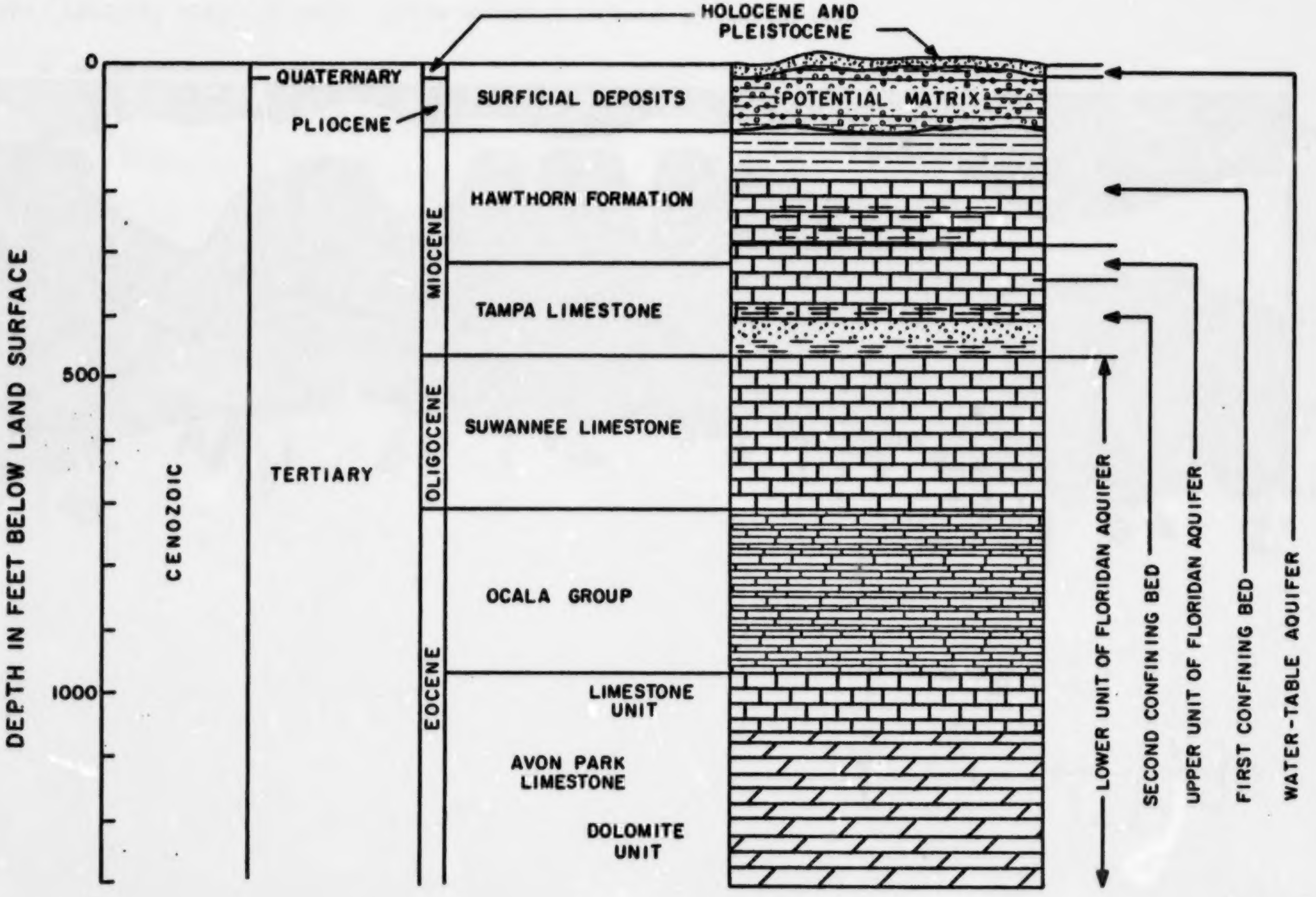
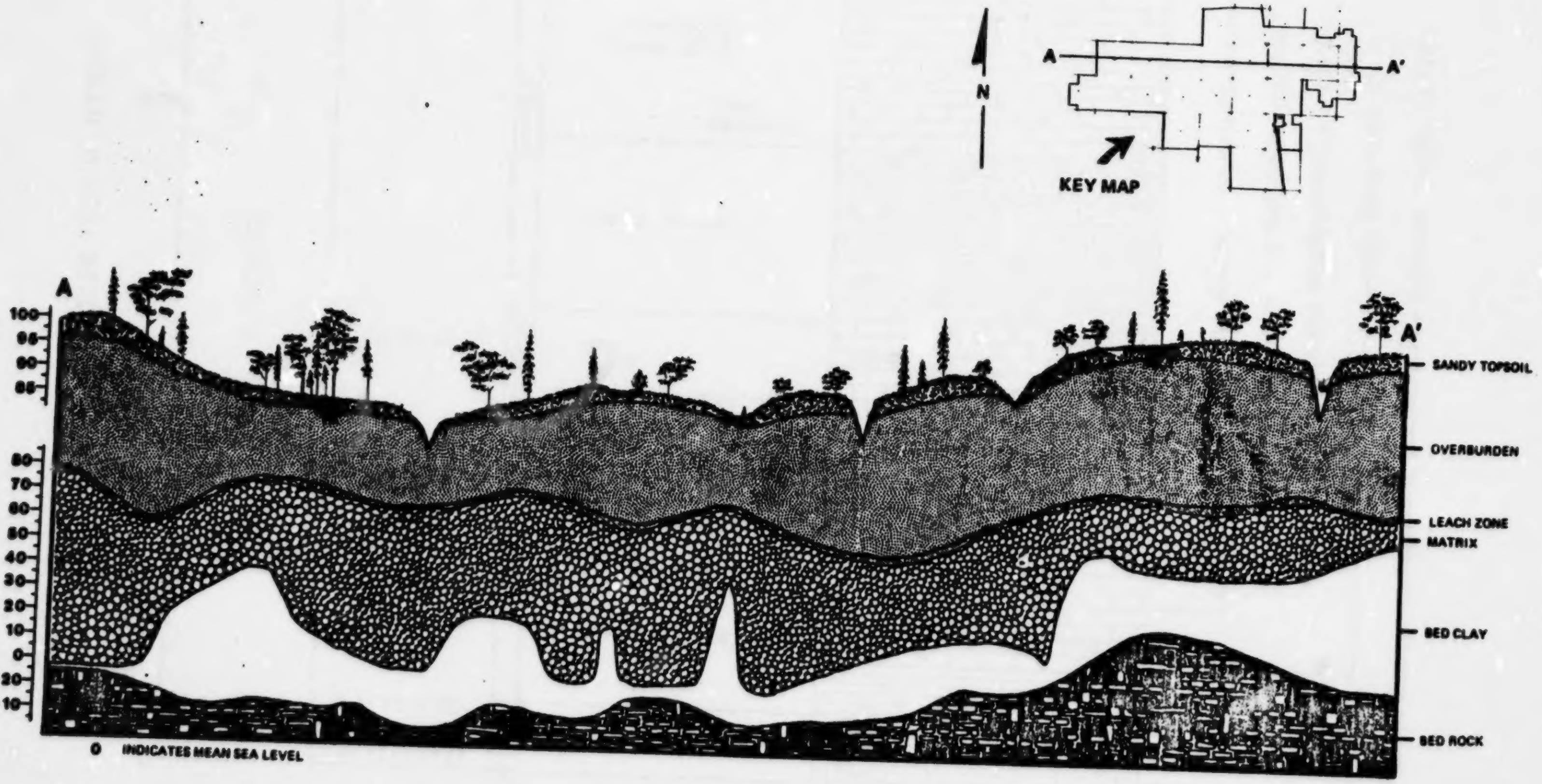

LETTIS CREEK
BRUSHY CREEK
HORSE CREEK
OAK CREEK
FT. GREEN – ONA RD.
S.C.L. R.R.
S.R. 64
S.R. 663
Ona
N
0
0.5
1
SCALE IN MILES
LEGEND:
⑧ SAMPLING LOCATIONS

Figure V-1 Sampling Locations for the Radiological Baseline Study


HOLOCENE AND PLEISTOCENE
DEPTH IN FEET BELOW LAND SURFACE
0
500
1000
CENOZOIC
QUATERNARY
PLIOCENE
TERTIARY
MIOCENE
OLIGOCENE
EOCENE
SURFICIAL DEPOSITS
HAWTHORN FORMATION
TAMPA LIMESTONE
SUWANNEE LIMESTONE
OCALA GROUP
LIMESTONE UNIT
AVON PARK LIMESTONE
DOLOMITE UNIT
POTENTIAL MATRIX
LOWER UNIT OF FLORIDAN AQUIFER
SECOND CONFINING BED
UPPER UNIT OF FLORIDAN AQUIFER
FIRST CONFINING BED
WATER-TABLE AQUIFER

SOURCE: MCC, 1977.

Figure V-2. Generalized Hydrogeologic Section.



N
A
A'
KEY MAP
A
A'
100
95
90
85
80
70
60
50
40
30
20
10
0
-20
-10
0 INDICATES MEAN SEA LEVEL
SANDY TOPSOIL
OVERBURDEN
LEACH ZONE
MATRIX
BED CLAY
BED ROCK

Note: Vertical scale in feet. Scale expanded between 80 and 85 feet.

Source: MCC, 1977.

Figure V-3. Subsurface Structure of the MCC Site.

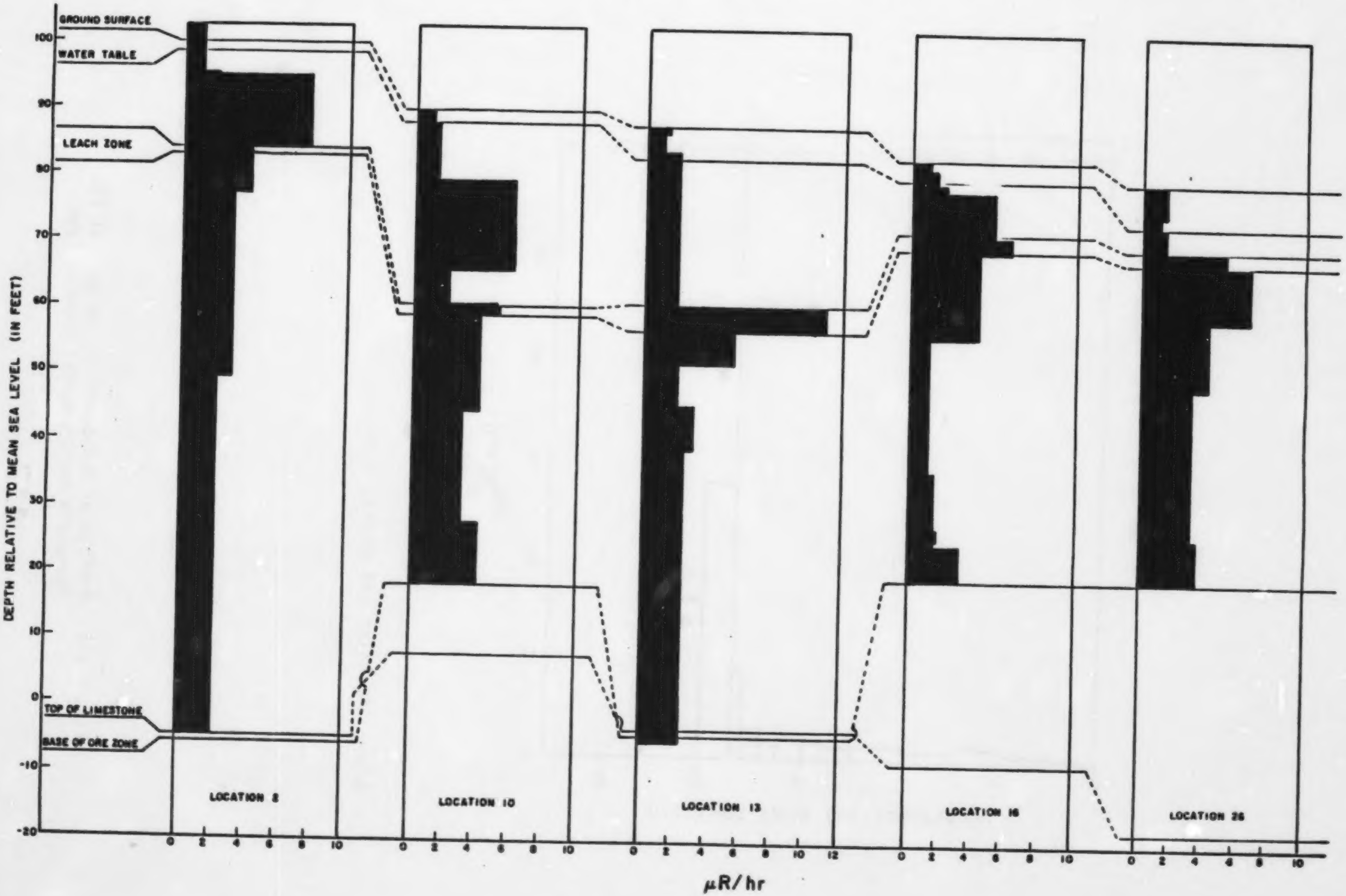
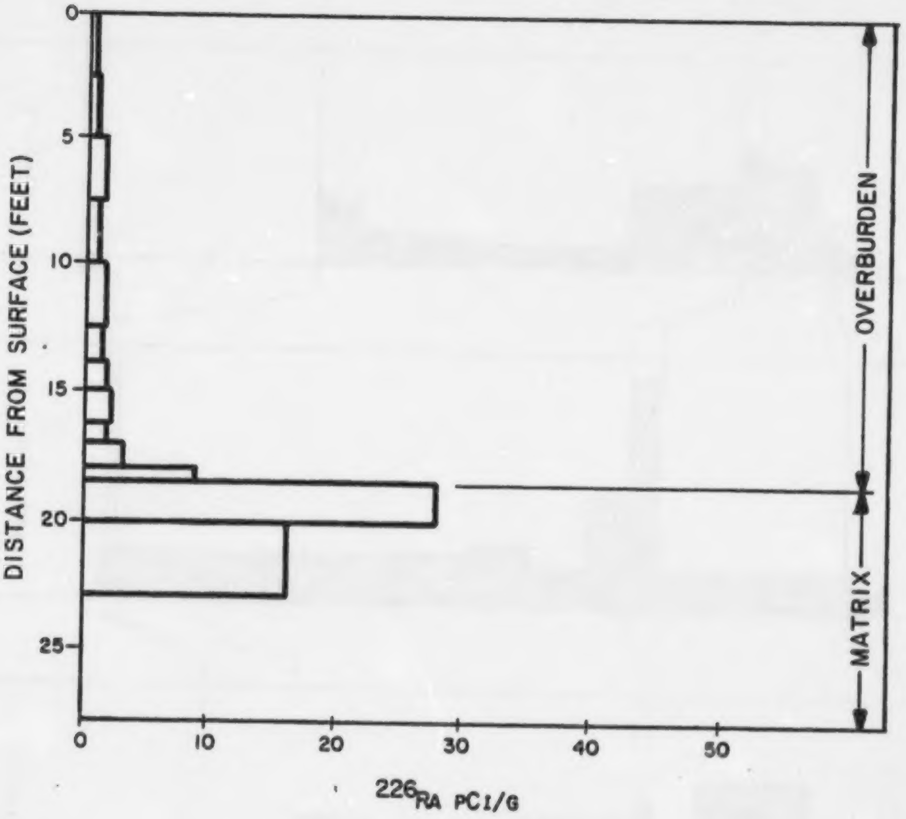


Figure V-4. Direct Gamma Radiation (μR/hr) in Composite Soil Cores.



After: Roessler and others, 1978b.

Figure V-5. Profile of Radioactivity in Central Florida Phosphate Region Normal Leached Zone.

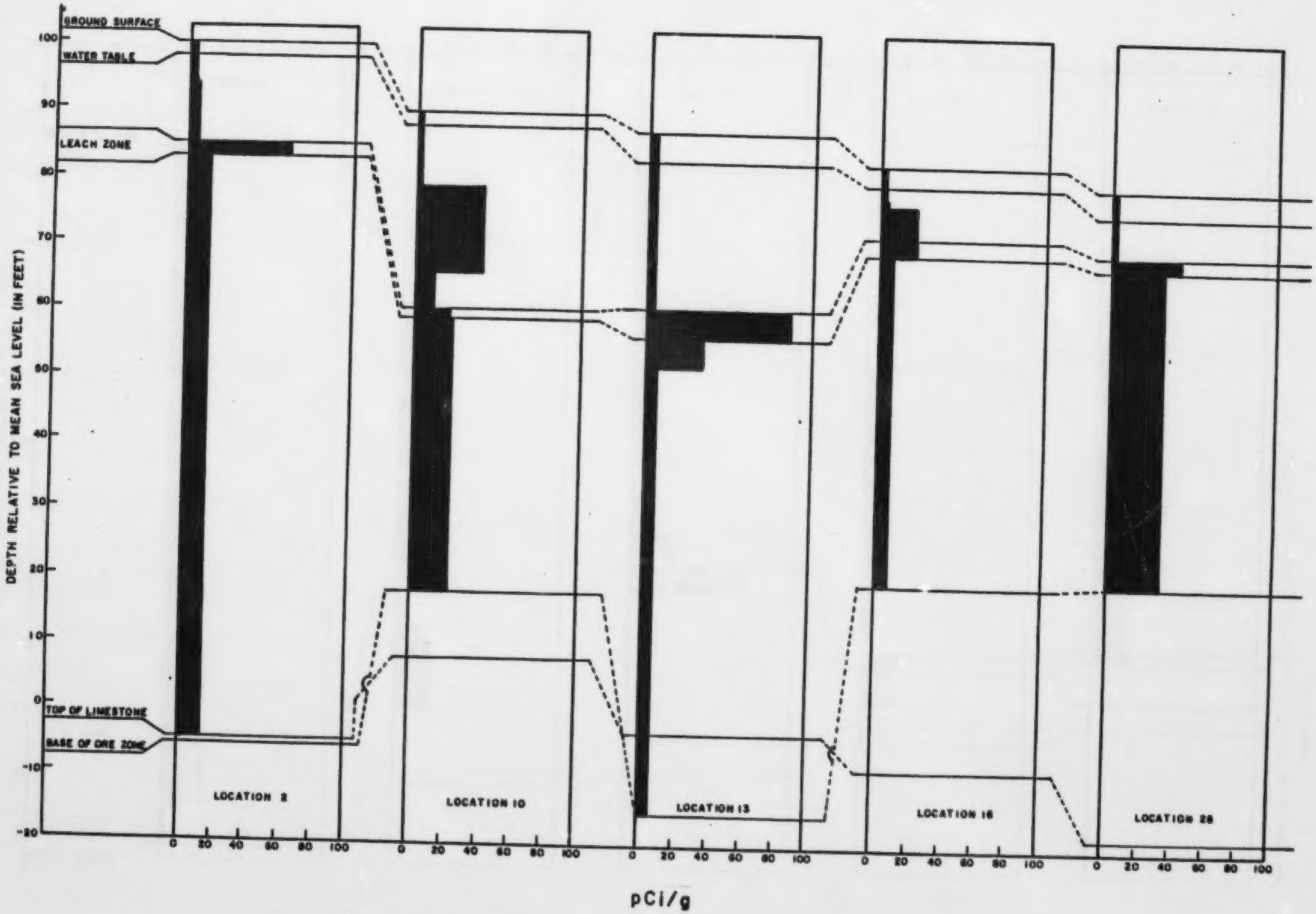


Figure V-6. Natural Uranium Activity (pCi/g dry) in Composite Soil Cores.

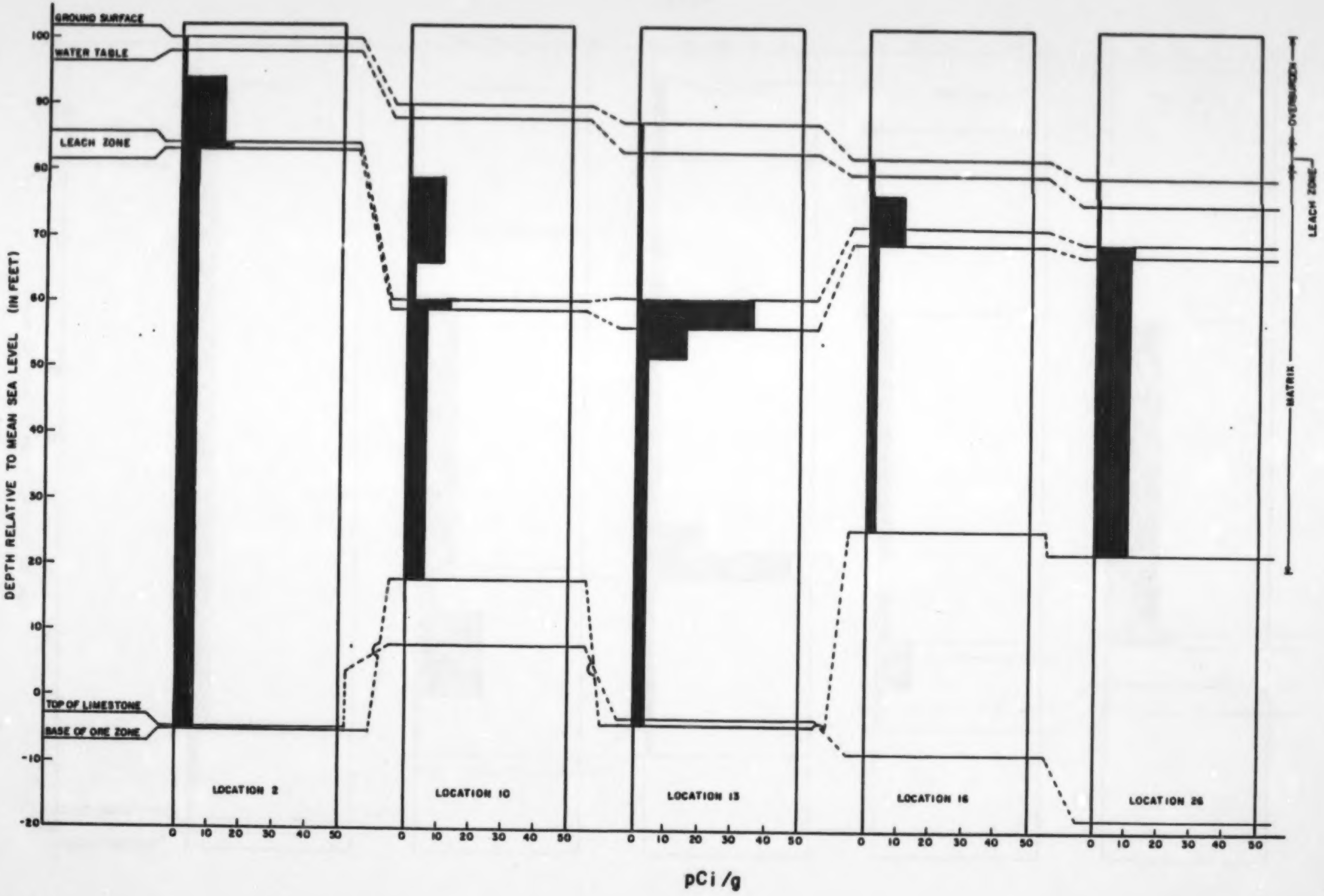
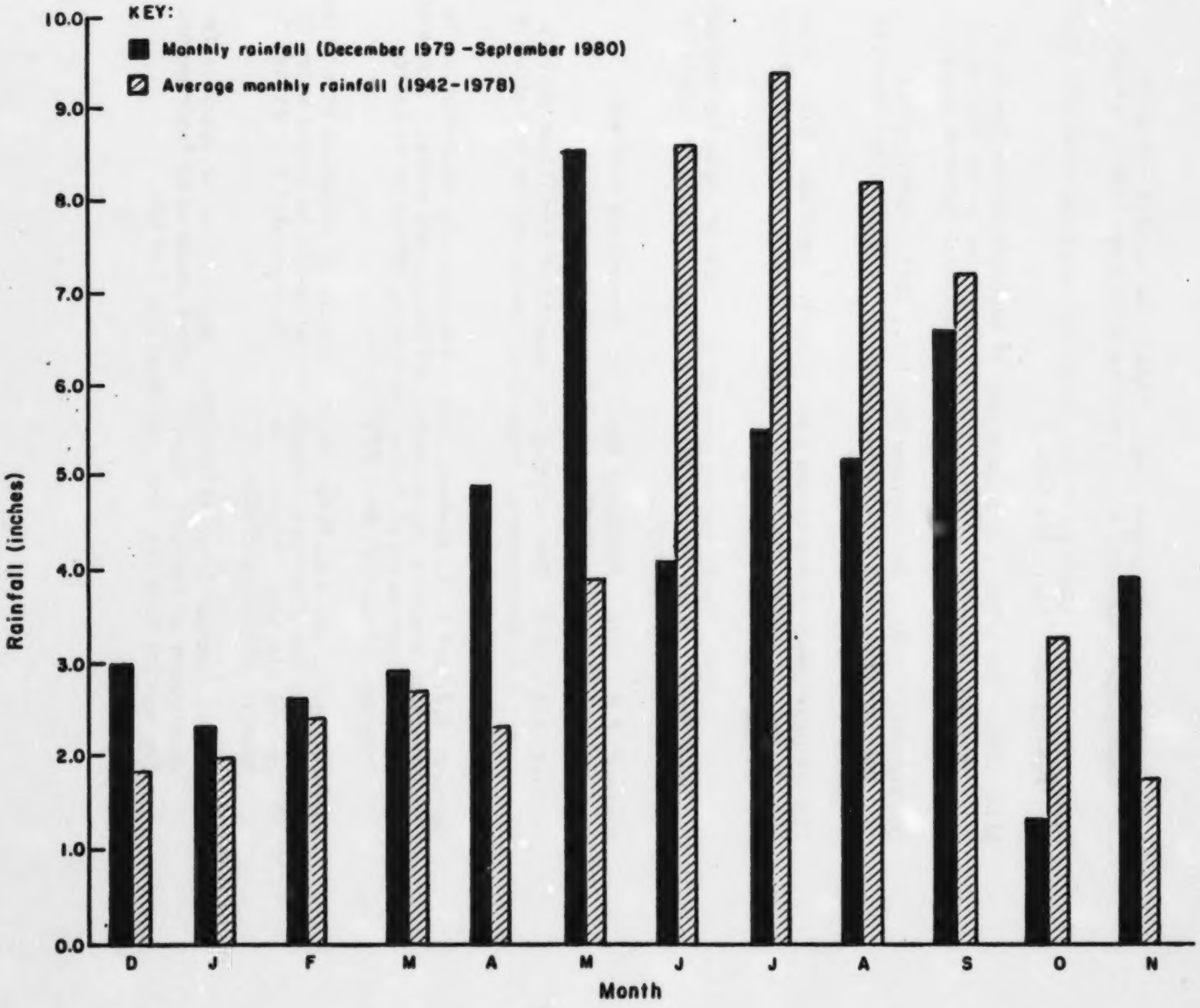


Figure V-7. Radium-226 Activity (pCi/g dry) in Composite Soil Cores.

Figure V-8. Monthly Rainfall Near Ona, Florida During the Period December 1979 to September 1980
Compared to 36 Year Average Monthly Rainfall
(Agricultural Research Center, I.F.A.S. Ona, Florida)



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# APPENDIX V-A

# SAMPLING AND ANALYSIS METHODOLOGY

## A.1 RADON FLUX

### A.1.1 Sampling Methodology

Radon flux is measured using the accumulator can method described by Bernhardt and others (1975). In that method, a steel drum with one open end is placed on the ground with the open end down. The drum is sealed to the ground by piling soil around the rim and tamping down the soil. The drum is equipped with a sample port and a pressure equalization port so that the drum pressure remains at barometric pressure. The radon concentration within the drum increases linearly with time as radon emanating from the ground is trapped.

The buildup of radon inside the drum is monitored by sampling at approximately 30, 60, and 90 minutes after placement of the drum. Air is withdrawn from the drum using a recirculating sampling system. The system is connected to the sampling and pressure equalization ports and consists of a small battery-powered air pump (MSA Monitair Sampler, Model S), a desiccator, a 47 mm glass fiber filter (Gelman, Type A/E), and an alpha scintillation cell. The desiccator and filter prevent introduction of moisture and particulate radon daughters into the cell.

The air pump is set at a flow rate of approximately 3.8 liters/min and runs for about 3 minutes, thus resulting in eight air changes in the 1.4 liter cell. This is sufficient to completely replace the nitrogen initially contained in the cell and does not significantly dilute the radon in the 30 gal (114 liters) drum. Sampling data recorded on the Radon Sampling Data Sheet (Table V A-1) include location, date, time of drum placement, time of sampling, sample pumping duration, and pump setting. Relevant meteorological conditions are also recorded.

### A.1.2 Counting Procedures

Exposed scintillation cells are held before counting to allow ingrowth of alpha-emitting radon daughters. The minimum holding time of 2.5 hours assures that daughter activities reach at least 95 percent of equilibrium. Equilibrated cells are counted using an Eberline SAC R-5 photomultiplier tube and Eberline MS-2 portable scaler/power supply. The time that counting begins, the counting time (duration), and the gross sample counts are recorded on the sheet in the field notebook.

Immediately after counting, the cell is purged with nitrogen. After at least four hours, the nitrogen-filled cell is counted to determine the background count rate for the next cell exposure. The date, time, counting time, and background counts are recorded in the field notebook. Background data are then transferred to the sample data sheet prior to the next cell exposure.

Calibration and performance testing are described in Section A.1.4.

### A.1.3 Data Processing

Calculation of radon flux involves linear regression analysis of radon concentrations versus time. Radon concentrations and counting errors are calculated using Equations A-1 and A-2, respectively. The lower limit of detection (LLD) is also calculated using Equation A-3, although undetectable radon concentrations are rarely encountered in flux determinations.

$$\text{Radon Conc. (pCi/l)} = \frac{\left(C_s/t_s - C_b/t_b\right)}{K \times D} \qquad \text{(A-1)}$$

$$\text{Counting Error (pCi/l)} = 2\frac{\sqrt{C_s/t_s{}^2 + C_b/t_b{}^2}}{K \times D} = 2\sigma \qquad \text{(A-2)}$$

$$\text{LLD (pCi/l)} = 4.66\frac{\sqrt{C_b/t_b{}^2}}{K \times D} = 4.66\sigma_b \qquad \text{(A-3)}$$

where:

$C_s$ = gross sample counts,
$C_b$ = background counts,
$t_s, t_b$ = sample and background counting times, respectively (min),
K = cell calibration factor (pCi/l/cpm), and
$\sigma$ = standard deviation of the net sample concentration,
$\sigma_b$ = standard deviation of the net background concentration, and
D = exp (- t), radon decay factor

where:

$\lambda$ = radon decay constant ($4.535 \times 10^{-4}$ $\text{min}^{-1}$), and
t = elapsed time betwen the midpoint of sample collection (pumping time) and the midpoint of counting.

Determination of the cell calibration factor is discussed in Section A.1.4.

Since all cells are held to allow alpha-emitting daughters to reach equilibrium before counting (including counting to determine efficiency), the correction for incomplete ingrowth discussed by Lucas and Woodward (1964) is not necessary.

The radon concentrations obtained increase linearly with time, as described by the equation:

$$y = mx + b \tag{A-4}$$

where:

$y$ = radon concentration (pCi/liter) at time, $t$,
$m$ = slope (pCi/liter-sec),
$x$ = elapsed seconds between placement of drum and time, $t$, and
$b$ = ambient air radon concentration (pCi/liter).

The slope, $m$, is determined using standard linear regression methods (Natrella, 1966). The radon flux (pCi/$m^2$-sec) is then obtained by multiplying the slope by the drum factor (liters/$m^2$). The drum factor is the ratio of the drum volume (in liters) to the surface area (in square meters) of the open end. The two sigma (standard deviation) error in the flux is estimated as twice the drum factor times the square of the variance of the slope.

### A.1.4 Calibration and Performance Testing

#### Alpha Scintillation Cells

The zinc sulfide-coated alpha scintillation cells are calibrated every six months or each time the coating is replaced, whichever is more frequent. The cells to be calibrated are connected in series to the sampling system described in Section A.1.1 and placed inside the Environmental Radon Chamber at the Environmental Measurement Laboratory (EML) of the U.S. Department of Energy (located in New York City), whose cooperation is gratefully acknowledged. The air pump is allowed to run for 5 to 10 minutes. The cells are then sealed and the actual radon concentration in the chamber obtained from the EML staff. The cells are returned to the Dames & Moore offices and, after allowing four hours' ingrowth, the cells are counted as described in Section A.1.2. The cell factors are then calculated using Equation A-1 after substitution of the chamber radon concentration.

### Counting Equipment

Each time the counting equipment, described in Section A.1.2, is moved to a new location, the proper high voltage setting must be established. This is accomplished by placing a thorium-230 source on a thin sheet of zinc sulfide in the center of the photomultiplier tube. Counts obtained in two-minute periods are plotted versus high voltage to determine the optimum high voltage setting (about 100 volts upscale from the onset of the "plateau region"). After setting the high voltage to the optimum setting, the thorium-230 source is recounted for 10 minutes. The counts obtained are then compared to the expected value, which is typically slightly less than 50 percent of the source alpha-emission rate since the counting geometry is $2\pi$. If the source count rate differs from the expected count rate by more than 4 to 5 percent in a 10-minute count, instrument operation is considered to be improper and steps are taken to determine and correct the cause before any samples are analyzed.

## Air Pump

The MSA air sampling pump is calibrated prior to each field program. Airflow rate versus rotometer setting is determined by measuring the time required for a soap bubble film to move a given number of graduations in a large-diameter volume-calibrated glass tube. Burets or graduated cylinders are normally used.

## Recordkeeping

Records of all calibrations and tests are kept in a radon field notebook.

## A.2 RADON CONCENTRATION

### A.2.1 Sampling Methodology

Composite air samples are collected over a 48-hour period using a low volume battery powered pulse pump (Environmental Measurements, Inc.). The pulse pump delivers a 1.5 ml pulse of air through a 47 mm glass fiber filter (Gelman, Type A/E) to a reinforced Mylar sample bag having a capacity of 15 liters. The pump is set to pulse at intervals of about 17 seconds so that the sample bag is filled in about 48 hours. The entire assembly is housed in a high impact plastic drum with an overhanging lid. Immediately following the end of the 48 hour period, the circulating air sampling system described in Section A.1.1 is used to fill an alpha scintillation cell.

Data recorded on the Radon Sampling Data Sheet (Table V A-1) includes the time and date composite sampling begins and ends, pumping time to fill the scintillation cells, and relevant meteorological conditions.

### A.2.2 Counting Procedures

The counting procedure is identical to that described in Section A.1.2 for radon flux measurements.

### A.2.3 Data Processing

Radon concentration, counting error, and lower limit of detection are calculated as described in Section A.1.3 using Equations A-1, A-2, and A-3, respectively. It should be noted that for ambient radon concentration calculations the elasped time, t, is measured from the midpoint of collection of the composite sample to the midpoint of counting.

### A.2.4 Calibration and Performance Testing

In addition to performing the calibrations and testing described in Section A.1.4, the flow rate of the pulse pump is checked prior to each sampling trip. The soap bubble method is used to adjust the pulse rate to achieve a flow of about 5 ml/min. Although the exact flow rate is not important, the pulse rate must be high enough to obtain a representative sample and low enough to avoid excessive filling of the sample bag.

## A.3 AIR PARTICULATE STUDY

### A.3.1 Sampling Equipment

Collection of a representative sample of airborne particulates for radionuclide determinations is accomplished using an Eberline regulated air sampler (RAS-1). The Eberline RAS-1 air sampling system was modified to include a Rockwell AL-250 dry gas meter to permit the measurement of the total air volume sampled.

The sampling train consists of an oil-less vacuum pump with a flow-rate regulator (the RAS-1 sampler), a dry gas meter (the Rockwell AL-250), a 1/4 inch inside-diameter (i.d.) galvanized pipe and a filter holder for a 47 mm glass-fiber filter. All connections use standard pipe fittings sealed with teflon tape for tight, leak resistant air connections.

The RAS-1 maintains a constant flow rate by automatic adjustment of a bypass valve in the pump regulator. The dry gas meter records cubic feet ($ft^3$) of air passing through it. An in-line U-type mercury manometer is placed between the filter assembly and the dry gas meter. The pressure drop across the filter can therefore be recorded after each filter replacement allowing the effects of the gradual loading of the filter to be observed and recorded. An increase in pressure drop would indicate filter loading or clogging. Pressure drops are maintained below 3.5 inches of mercury by changing filters. Typical pressure drops across new (unloaded) filters are about 2 inches of mercury.

### A.3.2 Data Collection and Analysis

The following readings are taken at each filter change and recorded on the Air Sampling Data Sheet (Table V A-2):

- Filter change sequence number (assigned numbering).
- Accumulated sampling time (hours).
- Date and time of filter change.
- Dry gas meter reading ($ft^3$).
- Desired rotometer setting (lpm).
- Actual rotometer setting (lpm).
- Desired filter pressure differential (in. Hg).
- Actual filter pressure differential (in. Hg).
- Daily average barometric pressure (in. Hg).
- Day and night average temperatures (°F).
- General weather conditions.

At the termination of a sampling sequence (required filter change), all of the above data is recorded and the sampling halted. The filters are removed from their holders and placed in glassine envelopes. New filters are placed in the holders and the samplers are switched on. All operating data is recorded again following start-up. All filters collected from one sampler during a single sampling run are combined and sent to a radiological laboratory for key radionuclide analysis.

Radionuclide activities on the collected filters are converted to airborne concentrations by dividing the collected activity (in picocuries or other appropriate unit) by the volume of air sampled (in $m^3$). The sampled air volume is obtained from the dry gas meter and corrected to yield the air volume at standard temperature and pressure using the following equation.

$$V_{std} = 17.7 \frac{V_m (P_b + P_m)}{T_m + 460} \qquad \text{(A-5)}$$

where:

$V_{std}$ = air volume (in $m^3$) at standard temperature and pressure (std), i.e., 70°F and 29.92 in Hg;

$V_m$ = metered air volume (in $m^3$);

$P_b$ = ambient barometric pressure (in in. Hg);

$P_m$ = average pressure drop across the filter (in in. Hg);

$T_m$ = average ambient temperature (in °F).

Radionuclide concentrations are thus reported in units of activity per $m^3$ of air at standard conditions.

### A.3.3 Calibration

The calibration procedure involves calibrating the rotometer on the sampler using a dry gas meter. Each dry gas meter has been tested at a flow rate of one-fifth (50 $ft^3$ per hour) of the rated capacity, and at a flow rate equal to or greater than the rated capacity (250 $ft^3$ per hour). These tests have shown that the accuracy of the dry gas meter is within one percent of the indicated flow (Connecticut, 1954).

Equipment used for the calibration procedure includes a sampling unit, dry gas meter, stop watch, and U-type tube manometers which are placed in-line between the filter assembly and the dry gas meter. The manometers measure the vacuum in the sampling line. When the rotometer on the sampling pump is manually adjusted, the vacuum in the sampling line changes. As the sampling rate is increased, the vacuum in the sampling line increases. The vacuum corresponding to each different rotometer setting is recorded.

The calibration procedure is conducted in two modes; with a filter and without a filter. The RAS-1 sampler, when operating with a filter, produces higher vacuums in the sampling line than when the unit is operating without a filter. The associated pressure drops are direct results of the resistance of the filter. Water manometers are used for calibration when pressure drops do not exceed 13.6 inches (one inch Hg). When pressure drops exceed this value, mercury filled manometers are used.

TABLE V A-1

## Radon Sampling Data Sheet

Job Name ____________________
Investigator ____________________
Site Location ____________________

Job No. ____________________
Sample Type ____________________
Sampler No. ____________________

| Run # | | 1 | 2 | 3 |
|---|---|---|---|---|
| **Field Data:** | | | | |
| Cell # | | | | |
| Sampling: Start-Date | | | | |
| -Time | | | | |
| Stop-Date | {Low-Vol. Radon Samplers Only} | | | |
| -Time | | | | |
| Midpoint-Date | | | | |
| -Time (1) | | | | |
| MSA Pump: Setting | | | | |
| Pump Start Time (1) | {Flux only} | | | |
| Pumping Duration (min) | | | | |
| Ambient Conditions: | | | | |
| Wind Speed (Est) | | | | |
| Temperature | | | | |
| Cloud Cover (Est) | | | | |
| Barometric Pressure | | | | |
| **Counting Data:** | | | | |
| Start-Date | | | | |
| -Time | | | | |
| Duration (min) | | | | |
| Mid Time (2) | | | | |
| Sample: | | | | |
| Gross Counts | | | | |
| Count Rate ±σ (cpm) | | | | |
| Background: | | | | |
| Gross Counts | | | | |
| Count Rate ±σ (cpm) | | | | |
| Cell LLD (pCi/l) | | | | |
| **Radon Concentration Calculations:** | | | | |
| Net Sample Count Rate ±σ (cpm) | | | | |
| Cell Factor ±σ (k) | | | | |
| Radon Concentration ±σ (pCi/l) | | | | |
| Decay Time (ΔT = 2-1) | | | | |
| Corrected Radon Conc. ±σ (pCi/l) | | | | |
| Cell Purge: Date | | | | |
| Time | | | | |

Comments:

# TABLE V A-2

## Air Sampling Data Sheet

SCHEMATIC OF
SAMPLE LAYOUT

COMMENTS

Plant ______
Date ______
Sampling Location ______
Sampler Type ______
Run Number ______
Operator ______
Sampler Type ______
Sampler I.D. Number ______
Meter I.D. Number ______

Indicate wind direction by arrow
for each filter change

READ & RECORD ALL DATA EVERY ___ HOURS

| Filter Change Number | Sampling Time (Hrs) | Clock Time (24-hr) | Gas Meter Reading $(V_m)$, $ft^3$ | Rotometer Setting | | Filter Pressure Differential $(\Delta H)$, in. Hg | | Barometric Pressure Avg. of Day | Ambient Conditions | | C-Cloudy<br>R-Rain<br>CL-Clear<br>W-Windy<br>CM-Calm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Desired | Actual | Desired | Actual | | Day Avg. Temp. | Night Avg. Temp. | |
| | | | | | | | | | | | |
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# APPENDIX V-B

# RADIOLOGICAL IMPACT ANALYSIS

## B.1 INTRODUCTION

This appendix: (a) discusses the methods used to estimate the radioactivity of beneficiation products and waste, (b) describes the derivation of source terms and other inputs to MILDOS (Gnugnoli and Martin, 1980), the computer code used to estimate radiological impacts on air quality, and (c) presents summaries of data input and output by the MILDOS code.

## B.2 RADIOACTIVITY OF BENEFICIATION PRODUCTS AND WASTES

Results of radiochemical analyses of pilot scale beneficiation products and wastes are not available for the MCC site. However, statewide and local data are available and can be used to estimate the activities of products and wastes.

Table V B-1 gives the activities of radium-226, uranium-238, and thorium-230 in Florida matrix, products, and wastes (Guimond and Windham, 1975). These values are based on 1973 data, which is representative of mines in the central Florida phosphate district (Polk and Hillsborough Counties). Since 1973, mining activities have increased in the south Florida phosphate district (which includes Hardee and Manatee Counties).

As seen in Table V B-2, the activity of south Florida materials is generally lower than that of those from central Florida. It is also apparent that product from the south Florida district contains more of the radioactivity, and the wastes contain less of the radioactivity originally present in the matrix than the central Florida district materials. The general decrease in radioactivity is due to the lower grade of matrix in the south Florida district. The shift in the distribution of radioactivity may be due to the higher yield of concentrate from south Florida district mines.

Since the depth-weighted activities of Ra-226 and U-238 in the MCC matrix are only 5.5 pCi/g and 7.9 pCi/g, respectively, the data given in Table V B-2 is more representative of the site. Accordingly, the data given in Table V B-2 was used to determine the distribution of radioactivity in product and waste mateials (Table V B-3), based on the measured radioctivity of the MCC matrix. The Th-230 activity was estimated by assuming secular equilibrium with U-238. The value for Pb-210 was based on limited data showing that Po-210, a daughter of Pb-210, is in secular equilibrium with Ra-226 in phosphate rock (Partridge and others, 1978).

The radionuclide activities given in Table V B-3 were used in Section B.3.2 to estimate source terms for analysis of air quality impacts. Data for waste materials (slimes and tailings) were used in Section 3.0 of this TSD to estimate impacts in other pathways.

## B.3 AIR QUALITY IMPACTS ANALYSIS

Impacts of the proposed action were evaluated using the MILDOS computer code (Gnugnoli and Martin, 1980) developed by USNRC for uranium mills. This code is well-suited in the form obtained from USNRC for estimated radiation doses to the public resulting from phosphate mining activities. This section describes the derivation of the data input to the code.

### B.3.1 Source of Airborne Radioactivity

The sources of airborne radioactivity generated by the proposed actions would fall into three generic categories: (1) dust from dragline operation, (2) particulate emissions from product drying and handling, and (3) radon emanations. For convenience, the life of the mine was considered in two separate phases: operational and post-reclamation. Fugitive dust emissions during construction of the facility were not considered. Radon emanations are considered in Section B.3.2.

### B.3.1.1 Operational Emissions

During the operational phase, radioactive particulates would be released from the emission control devices servicing the rock dryer (Source #1), dry rock storage silos (Source #2), and loadout stations (Source #3). The locations of these sources are shown on Figure V B-1. As indicated in Table V B-4, the eight storage silos would be served by two wet scrubbers, one to control emissions from incoming rock and one to control emissions as the rock was transferred to the loadout stations. Each of the two loadout stations would also be equipped with a wet scrubber. Each pair of scrubbers was treated as a single point source since they would not be widely separated and would have identical stack heights.and exit velocities. The particulate release rates given in Table V B-4 are conservative in that they over-estimate releases by assuming 24 hour/day, 365 day/year operation.

Particulates would also be released during stripping of the overburden and mining of the matrix. Release rates from these activities are difficult to estimate due to the lack of data for Florida phosphate mining operations. Following Ochsner and Blackwood (1978), values of 25 grams of particulates per metric ton (g/MT) of overburden stripped and 0.4 g/MT of matrix mined were assumed. These values were based on data for dragline mining at a moist environment, open-pit copper mine in Montana. Since the water table on the MCC site varies from 0 to 5 feet below the surface, and the matrix lies below the water table, these values are considered to be quite conservative.

Several additional assumptions were necessary to obtain the dragline particulate emissions given in Table V B-5. The total metric tons of matrix and overburden moved during the 31.5-year life of the mine were estimated to be 921.3 million cubic yards and 66.3 million cubic yards, respectively (MCC, 1977). The number of cubic yards of overburden stripped was calculated as the difference between the total cubic yards calculated from the given pit depths and areas and the total cubic yards of matrix mined (MCC, 1977). The resultant volumes were converted to weights using a density of 1.22 $MT/yd^3$.

Although the MILDOS code can accommodate area as well as point sources, it limits area sources to a maximum of 0.1 $km^2$ each and limits the total number of sources to twenty. Accordingly, the site was divided into four sections, each with a point source at approximately its center (Figure V B-1). Emission rates due to dragline operations were then distributed among these sources on the basis of the percentage of reclaimed acreage lying within each section.

### B.3.1.2 Post-Operational Emissions

The post-operational phase would begin 42 years after initiation of mining and 10.5 years after cessation of beneficiation. It was assumed that particulate releases during this phase would be comparable to those before mining began and would, therefore, not constitute an impact. This would leave radon emanation (discussed in Section B.3.2) as the only source of airborne radioactivity.

### B.3.2 Source Terms

This section describes the estimation of source terms for particulate U-238, Th-230, Ra-226, and Pb-210 activities, and gaseous Rn-222.

#### B.3.2.1 Operational Phase

Particulate source terms were obtained directly from the data given in Tables V B-3, V B-4, and V B-5. Particulates from the rock dryer, storage silos, and loadout stations were obtained by multiplying the radionuclide concentrations in the product (Table V B-3) by the particulate release rates given in Table V B-4.

It was assumed that 100 percent of these particulates would have effective diameters of 1.0 µm or less. Published data (Ochsner and Blackwood, 1978; USEPA, 1979) on the size distribution of rock dryer particulates indicate that the majority of particulates have diameters between 1.0 and 10 µm. The assumed distribution was conservative in that the smaller particulates would deliver a larger radiation dose to the lungs.

It was assumed that there would be no increase in Rn-222 flux from the site surface relative to baseline conditions. While it is true that mining would expose materials with Ra-226 contents greater than the 1.0 pCi/g of the existing surficial materials, the exposed material would all be moist and would frequently be under water. As seen below, increasing soil moisture content would significantly reduce radon flux, and virtually no Rn-222 would be released to the atmosphere from submerged matrix and overburden.

On the other hand, Rn-222 would be released during product drying and handling (Sources #1, #2, and #3). The radon gas would be produced by the radioactive decay of Ra-226 contained in grains of the phosphate product. Obviously, some of the radon would be generated inside these grains and would not be released unless it reached the surface of the grain before it decayed. The fraction of generated radon actually escaping the grains is quantified by the emanation coefficient, E. If these grains were part of a bulk material (e.g., product in the storage silos), the emanated radon would also have to diffuse through bulk material and reach its surface to become airborne. The rate of diffusion ($cm^2/sec$) is expressed by the effective bulk diffusion coefficient, D. Additional amounts of radon would be lost to decay during diffusion.

The diffusion coefficient decreases with increasing moisture content of the porous medium. For moisture content, M, in the range of 0 to 23 weight percent, the relationship would be (Roessler, 1978b):

$$D = [0.05\ cm^2/sec]\ [\exp(-0.1\ M)] \qquad \text{(Eq. B-1)}$$

The MCC rock dryer would be designed to reduce the moisture content of the product from 13 weight percent to 2 weight percent (Environmental Science and Engineering, 1981). Substituting into Equation B-1 yields a diffusion coefficient of $4.09 \times 10^{-2}$ $cm^2/sec$.

The rate of escape (flux) of radon from the surface of the bulk material can be expressed as:

$$J = 10^4 \frac{cm^2}{m^2} \cdot C_{Ra} \cdot E \cdot \rho\sqrt{\frac{\lambda D}{P}} \qquad \text{(Eq. B-2)}$$

where:

$J$ = radon flux ($pCi/m^2$-sec)
$C_{Ra}$ = Ra-226 concentration of the material (pCi/g)
$\rho$ = material bulk density ($g/cm^3$)
$\lambda$ = Rn-222 decay constant ($2.1 \times 10^6$/sec)
$P$ = porosity

and the other quantities are as defined above. Equation B-2 is applicable to an infinitely thick, homogeneous, radium-containing material. The equation for flux for a homogeneous material of finite thickness reduces to Equation B-2 for thickness of 6 feet (1.8 m) or greater.

In estimating the radon flux of the dry product, the material was assumed to resemble fine, very porous waste clays (slimes), with the exception that it was assumed to have the density of crystalline phosphorous pentoxide, $P_2O_5$, (2.4 g/cm$^3$) rather than the bulk density of slimes (0.86 g/cm$^3$). The assumed density was conservative in that it increased the flux by a factor of 2.8. Typical slimes have an emanation coefficient of 0.16 and a porosity of 0.5 (Roessler, 1978a). Substitution of these values and the diffusion coefficient of $4.09 \times 10^{-2}$ cm$^2$/sec calculated from Equation B-1 into Equation B-2 yields a flux of 24.8 pCi/m$^2$-sec for the dry product.

The combined processing capacity of the two loadout stations is equivalent to that of the rock dryer. Although the product would not be purged by fluidizing air during loadout, it was conservatively assumed that all radon emanated would be released, yielding a radon source term identical to that for the rock dryer (8.75 Ci/yr).

Between drying and loadout, the product would be stored in a bank of eight silos, each with a height of 29.6 m and diameter of 15.2 m. Estimation of the radon source term was complicated by several factors. Each silo would be filled and emptied in approximately eight days, preventing buildup of equilibrium radon concentrations and, because the product would tend to form a cone, a three-dimensional flux model was relevant rather than the one-dimensional model on which Equation B-2 was based. These two factors would tend to cancel each other. For simplicity it was assumed that:

- Equilibrium concentrations of radon would be maintained.
- The product would form a cone with a height equal to its radius (total active surface area for all eight silos = 437 m$^2$).
- Equation B-2 was applicable.

These assumptions yielded a radon source term of 2.73 Ci/yr for the bank storage silos.

### B.3.2.2 Post-Operational Phase

As discussed in Section B.3.1, it was assumed that radon emanation from reclaimed lands would be the only source of airborne radioactivity during the post-operational phase. Two waste disposal/reclamation alternatives were considered: (1) conventional, separate disposal of slimes and tailings with land-and-lakes reclamation, and (2) conventional disposal with sand/clay caps, eliminating most lakes and minimizing above-grade clay storage (proposed action). Division of the property into four sections (Figure V B-1) for source term estimation is also discussed in Section B.3.1.

#### Conventional Waste Disposal with Land-and-Lakes Reclamation

This method of waste disposal and land reclamation was originally planned by MCC. After reclamation, the land would consist of four types of surfaces (MCC, 1977): (1) reclaimed slimes disposal areas, (2) reclaimed sand tailings disposal areas, (3) lakes, and (4) undisturbed land. Table V B-6 summarizes the area of each land type in each of the four sections (Sources #4 through #7).

The radon source terms were calculated to show the increase, if any, in radon releases relative to that of the undisturbed site. Source terms for each material type given in Table V B-8 were calculated from the areas given in Table V B-6 and radon fluxes in Table V B-7. It was assumed that reclaimed slimes and sand tailings would be capped with overburden, which would include leached zone material, making the assumption conservative. Virtually no radon would be released from areas covered by lakes due to the diffusion coefficient of about $10^{-5}$ $cm^2$/sec for water (Tanner, 1965).

#### Sand/Clay Mix Cap Waste Disposal and Reclamation (Proposed By MCC)

The land-and-lakes reclamation plan considered in the previous sections was replaced as the proposed action because of concern over the extent of above-grade clay disposal areas. The final proposed plan was designed to minimize above-grade disposal of waste clays and, as a consequence, larger areas of the site would be covered with radonem ating materials. However, as shown in this section, use of four fo thick, mixed sand/clay caps and thinner overburden covers in the fi l proposed plan would result in an overall reduction in releases of ai orne radioactivity. Analyses of radiological impacts during the op ational phase of the facility were not affected.

The proposed plan calls for four types of reclaimed lands: (1 undisturbed overburden, (2) capped slimes, (3) covered slimes, and (4 covered tailings. Approximately 400 acres of lakes created over wa e tailings and slimes were conservatively ignored (i.e., the sub- me ed wastes were treated as dry and exposed on the surface). Radium-22 concentrations in the upper six feet of the reclaimed lands are su arized in Table V B-9. Acreages of the reclaimed lands are given in able V B-10. The tabulated values were calculated using the me ods described for the conventional disposal/reclamation plan.

Caps for slimes disposal areas would consist of eight parts by we ht tailings and one part by weight slimes. Overburden covers would re lt from spreading of dikes and overburden spoil piles surrounding th remaining slimes and tailings disposal areas. These covers would no completely cover all such areas and would vary in thickness. Ex- pe ence at other mines indicates that these covers, where they exist, wo d rarely exceed one foot in thickness. Accordingly, it was con- se atively assumed that all such areas were completely covered by one fo of overburden.

Radon fluxes of the reclaimed lands are given in Table V B-11. So ce terms derived from these fluxes and the land areas given in Ta e V B-10 are given in Table V B-12. A summary of source terms in t to the MILDOS computer code is provided in Table V B-13.

## B. 3 Population Distribution

A relevant population distribution could not be located in the li rature. This section briefly describes the methods used to obtain th distribution given in Table V B-14. The distribution was centered, to he extent possible, on the rock dryer and extended 80 km in all directions. The area was divided into 16 segments, each bisected by the 16 compass points. As indicated in Table V B-14, each segment was further subdivided into annular sections corresponding to various radii from the dryer.

Out to a distance of 5 kilometers, USGS quadrangle maps were used to locate individual dwellings within each of the 64 sectors. It was assumed that each dwelling was occupied by the average-sized Florida family which consists of 2.5 people (Kallenborn, 1980).

Beyond 5 kilometers, a larger map was used to locate communities and counties within the remaining sectors. Where available, populations of communities were added to populations per unit area (University of Florida, 1979; Florida Department of Commerce, 1979).

### B.3.4 Miscellaneous Inputs

This section gives references and sources for the remaining significant inputs to the MILDOS code.

### B.3.4.1 Meteorological Data

The code requires wind frequency distributions for each of six wind speed classifications and that of the six Pasquill stability classes. This information was compiled from the National Weather Service Star Output for Tampa, Florida during 1971 to 1975 and is presented in Table V B-15. An average mixing height of 1,000 m was taken from the AIREM Program Manual (Martin and others, 1974).

### B.3.4.2 Food Production

When provided with areal food production rates, the MILDOS code includes ingestion pathways in dose assessments. The estimated production rates were:

| | |
|---|---|
| Vegetables | 483,000 kg/km$^2$-yr |
| Meat | 2,310 kg/km$^2$-yr |
| Milk | 7,495 kg/km$^2$-yr |

These rates were derived from 1979 Hardee County crop production data obtained from the Florida Crop and Livestock Reporting Service and the Florida Citrus Manual. The rates were adjusted to reflect the percentage of available land actually in production (extrapolated from Hardee County to the other eight counties within 80 km of the site) but were not adjusted to reflect export of foodstuffs from the region. Since the region includes several large, non-food producing urban areas, and since a substantial portion of the citrus crop, the major crop in the region is exported, calculated ingestion doses are extremely conservative.

## TABLE V B-1

## ESTIMATED ACTIVITIES (pCi/g) OF RADIUM-226, URANIUM, AND THORIUM IN FLORIDA PHOSPHATE MINE PRODUCTS AND WASTES IN 1973[a]

| | Ra-226 | U-238 | Th-230 |
|---|---|---|---|
| Matrix[b] | 27.5 | 26.3 | 26.9 |
| Marketable Rock | 41.7 | 41.3 | 42.3 |
| Slimes | 44.9 | 44.3 | 47.7 |
| Sand Tailings | 7.5 | 5.3 | 4.0[c] |

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[a] Source: Guimond and Windham, 1975.

[b] Calculated from total tons of matrix, rock, slimes, and tailings, and activities given above for the latter three materials.

[c] Texas Instruments, 1978.

## TABLE V B-2

## ACTIVITIES OF RADIUM-226 AND URANIUM-238 IN FLORIDA PHOSPHATE MINE PRODUCTS AND WASTES ESTIMATED FROM RECENT DATA[a]

| | Activity (pCi/g) | |
|---|---|---|
| | Ra-226[a,b] | U-238[c] |
| Matrix | 12.3 | 14.5 |
| Product | 34.8 | 39.2 |
| Slimes | 11.5 | 14.8 |
| Tailings | 1.7 | 2.0 |

---

[a] Sources: Dames & Moore, 1981; Farmland Industries, 1979; USEPA, 1980; and unpublished data.

[b] Activities given are geometric means of individual results reported in the sources cited.

[c] Estimated using the U/Ra ratios from USEPA (1980).

## TABLE V B-3

## ESTIMATED ACTIVITIES (pCi/g) OF Ra-226, U-238, Th-230, AND Pb-210 IN MCC OVERBURDEN, MATRIX, MINE PRODUCTS, AND WASTES

| | Ra-226 | U-238 | Th-230 | Pb-210[a] |
|---|---|---|---|---|
| Overburden | 6.2[b,c] | 7.1[b,c] | 7.1 | 6.2 |
| Matrix | 5.5[b] | 7.9[b] | 7.9 | 5.5 |
| Product | 15.6 | 21.3 | 21.3 | 15.6 |
| Slimes | 5.1 | 8.1 | 8.1 | 5.1 |
| Sand Tailings | 0.8 | 1.1 | 1.1 | 0.8 |

---

[a] Based on data given by Partridge and others, 1978 for phosphate rock.

[b] Depth-weighted averages of composites from five boreholes (Table V-10).

[c] Includes leached zone.

## TABLE V B-4

## PARTICULATE RELEASE PARAMETERS FOR EMISSION CONTROL DEVICES

| Source | | Particulate Release Rate[a] (g/yr) | Stack Height (m) | Exit Velocity (m/sec) |
|---|---|---|---|---|
| Source #1 | | | | |
| Rock Dryer | | 8.06E7[b] | 46.3 | 14.3 |
| Source #2 | | | | |
| Scrubber #1 | | 8.82E6 | 41.1 | 14.3 |
| Scrubber #2 | | 2.27E7 | 41.1 | 14.3 |
| | Total | 3.15E7 | | |
| Source #3 | | | | |
| Scrubber #1 | | 1.25E7 | 18.3 | 14.3 |
| Scrubber #2 | | 1.25E7 | 18.3 | 14.3 |
| | Total | 2.50E7 | | |

---

Source: Environmental Science and Engineering, Inc., 1980.

[a] Based on 24 hr/day, 365 day/yr operation.
[b] 8.06E7 = 8.06 x $10^7$.

## TABLE V B-5

## PARTICULATE RELEASE RATES FROM DRAGLINE OPERATIONS

| Source | Area ($km^2$) | Overburden Stripping | Matrix Mining | Total |
|---|---|---|---|---|
| Source #4 (East Section) | 8.66 | 1.55E7[a] | 3.41E6 | 1.89E7 |
| Source #5 (South Section) | 4.95 | 8.91E6 | 1.95E6 | 1.09E7 |
| Source #6 (North Section) | 12.8 | 2.30E7 | 5.04E6 | 2.80E7 |
| Source #7 (West Section) | 9.67 | 1.74E7 | 3.81E6 | 2.12E7 |

---

[a] 1.55E7 = 1.55 x $10^7$

## TABLE V B-6

## AREAS OF RECLAIMED LAND TYPES
## CONVENTIONAL WASTE DISPOSAL WITH LAND-AND-LAKES RECLAMATION

| | Area (acres) | | | | |
|---|---|---|---|---|---|
| | Slimes | Tailings | Lake | Undisturbed[a] | Total |
| Source #4 (East Section) | 2,628 | 95 | 0 | 847 | 3,570 |
| Source #5 (South Section) | 0 | 140 | 1,415 | 484 | 2,039 |
| Source #6 (North Section) | 2,746 | 591 | 674 | 1,248 | 5,259 |
| Source #7 (West Section) | 2,167 | 20 | 850 | 945 | 3,982 |
| Total | 7,541 | 846 | 2,939 | 3,524 | 14,850 |

---

[a] Calculated as difference between total site area and total reclaimed area. Distributed in proportion to fraction of reclaimed land in each section.

## TABLE V B-7

## RADON FLUX FROM RECLAIMED LANDS
## CONVENTIONAL WASTE DISPOSAL WITH LAND-AND-LAKES RECLAMATION

| Land Type | Ra-226 Concentration in Upper Six Feet (pCi/g) | Flux Predictor[a] (pCi/$m^2$-sec per pCi/g Ra-226) | Radon Flux (pCi/$m^2$-sec) |
|---|---|---|---|
| Slimes with 4 foot OB Cap[b,c] | 5.8 | 0.27 | 1.58 |
| Sand tailings with 4 foot OB Cap[b,c] | 4.4 | 0.27 | 1.19 |
| Undisturbed OB | 1.0 | 0.53 | 0.53 |

---

[a] Source: Roessler, 1978a.

[b] OB = spoiled overburden (includes leached zone). Ra-226 concentration = 6.2 pCi/g.

[c] Slimes Ra-226 concentration = 5.1 pCi/g.

[d] Sand tailings Ra-226 concentration = 0.8 pCi/g.

## TABLE V B-8

## POST-OPERATIONAL RADON SOURCE TERM
## CONVENTIONAL WASTE DISPOSAL WITH LAND-AND-LAKES RECLAMATION

| Material | Source Term (Ci/yr) | | | |
|---|---|---|---|---|
| | Source #4 | Source #5 | Source #6 | Source #7 |
| Reclaimed Slimes | 530 | 0 | 554 | 436 |
| Reclaimed Sand Tailings | 14 | 21 | 90 | 3 |
| Undisturbed Overburden | 57 | 33 | 84 | 64 |
| Total | 602 | 54 | 728 | 503 |
| Baseline Overburden | 242 | 138 | 356 | 270 |
| Source Term | 360 | -138[a] | 372 | 233 |

---

[a] Source term of 0 used for MILDOS input.

## TABLE V B-9

## RADIUM-226 CONCENTRATIONS OF MATERIALS FOR PROPOSED RECLAMATION PLAN

| | Radium-226 (pCi/g) |
|---|---|
| Undisturbed Overburden | 1.0 |
| Overburden[a] for Covers | 4.0 |
| Clay (Slimes) | 5.1 |
| Sand (Tailings) | 0.8 |
| Sand/Clay Caps[b] | 1.3 |
| Capped Slimes[c] | 2.6 |
| Covered Slimes[d] | 4.9 |
| Covered Tailings[d] | 1.3 |

---

[a] Excludes leached zone, which is to be selectively spoiled in the bottom of the mine cut.

[b] Sand/clay ratio = 8.

[c] Four foot-thick sand/clay cap (SCR = 8).

[d] Assumed one foot-thick overburden cover.

## TABLE V B-10

## AREAS OF RECLAIMED LANDS FOR PROPOSED RECLAMATION PLAN

| | Area (Acres) | | | | |
|---|---|---|---|---|---|
| | Capped Slimes | Covered Slimes | Covered Tailings | Undisturbed[a] | Total[b] |
| Source #4 (East Section) | 2,176 | 351 | 126 | 1,164 | 3,817 |
| Source #5 (South Section) | 0 | 1,365 | 123 | 652 | 2,140 |
| Source #6 (North Section) | 1,447 | 1,748 | 538 | 1,640 | 5,373 |
| Source #7 (West Section) | 470 | 1,488 | 488 | 1,074 | 3,520 |
| Total | 4,093 | 4,952 | 1,275 | 4,530 | 14,850 |

---

[a] Calculated as difference between total site area and total reclaimed area. Distributed in proportion to fraction of reclaimed land in each section.

[b] Total acreage in each sectional source differ from those given in Table V B-6 due to slight differences in reclamation plan and resulting distribution of undisturbed lands.

## TABLE V B-11

## RADON FLUX FROM RECLAIMED LANDS - PROPOSED RECLAMATION PLAN

| Land Type | Ra-226 Concentration in Upper Six Feet (pCi/g) | Flux Predictor[a] (pCi/m$^2$-sec for pCi/g Ra-226) | Radon Flux (pCi/m$^2$-sec) |
|---|---|---|---|
| Undisturbed Overburden | 1.0 | 0.53 | 0.53 |
| Capped Slimes | 2.6 | 0.27 | 0.70 |
| Covered Slimes | 4.9 | 0.27 | 1.32 |
| Covered Tailings | 1.3 | 0.27 | 0.35 |

---

[a] See Table V-6.

## TABLE V B-12

## POST-OPERATIONAL RADON SOURCE TERMS - PROPOSED RECLAMATION PLAN

| Material | Source Term (Ci/yr) | | | |
|---|---|---|---|---|
| | Source #4 | Source #5 | Source #6 | Source #7 |
| Capped Slimes | 195 | 0 | 129 | 42 |
| Covered Slimes | 59 | 230 | 295 | 251 |
| Covered Tailings | 6 | 6 | 24 | 22 |
| Undisturbed Overburden | 79 | 44 | 111 | 73 |
| Total | 339 | 280 | 559 | 388 |
| Baseline Overburden | 258 | 145 | 364 | 238 |
| Source Term | 81 | 135 | 195 | 150 |

## TABLE V B-13

## SUMMARY OF SOURCE TERMS

|  | COORDINATES |  |  | SOURCE TERM |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| SOURCE NAME | KM X | KM Y | M Z | U-238 | TH-230 | CI/YEAR RA-226 | PB-210 | RN-222 | PSIZE[a] SET | M/SEC. EXIT VEL. |
| 1. Operational (With Rock Dryer) |  |  |  |  |  |  |  |  |  |  |
| Rock Dryer | 0.00 | 0.00 | 46.30 | 1.72E-03 | 1.72E-03 | 1.25E-03 | 1.25E-03 | 8.75E+00 | 2 | 1.43E+01 |
| Storage Silos | 0.01 | -0.08 | 41.10 | 6.71E-04 | 6.17E-04 | 4.91E-04 | 4.91E-04 | 2.73E+00 | 2 | 1.43E+01 |
| Loadout Stations | 0.11 | -0.10 | 18.30 | 5.33E-04 | 5.33E-04 | 3.90E-04 | 3.90E-04 | 8.75E+00 | 2 | 1.43E+01 |
| Generalized Source E | 2.59 | -0.85 | 2.83 | 1.38E-04 | 1.38E-04 | 1.15E-04 | 1.15E-04 | 0. | 3 | 0. |
| Generalized Source S | -1.34 | -4.65 | -6.96 | 7.87E-05 | 7.87E-05 | 6.59E-05 | 6.59E-05 | 0. | 3 | 0. |
| Generalized Source N | -1.34 | -1.43 | -1.74 | 2.04E-04 | 2.04E-04 | 1.71E-04 | 1.71E-04 | 0. | 3 | 0. |
| Generalized Source W | -6.21 | -1.34 | -3.26 | 1.54E-04 | 1.54E-04 | 1.29E-04 | 1.29E-04 | 0. | 3 | 0. |
| 2. Operational (Without Rock Dryer) |  |  |  |  |  |  |  |  |  |  |
| Generalized Source E | 2.59 | -0.85 | 2.83 | 1.38E-04 | 1.38E-04 | 1.15E-04 | 1.15E-04 | 0. | 3 | 0. |
| Generalized Source S | -1.34 | -4.65 | -6.96 | 7.87E-05 | 7.87E-05 | 6.59E-05 | 6.59E-05 | 0. | 3 | 0. |
| Generalized Source N | -1.34 | -1.43 | -1.74 | 2.04E-04 | 2.04E-04 | 1.71E-04 | 1.71E-04 | 0. | 3 | 0. |
| Generalized Source W | -6.21 | -1.34 | -3.26 | 1.54E-04 | 1.54E-04 | 1.29E-04 | 1.29E-04 | 0. | 3 | 0. |
| 3. Post-Operational (Conventional Waste Disposal With Land-and-Lakes Reclamation) |  |  |  |  |  |  |  |  |  |  |
| Generalized Source E | 2.59 | -0.85 | 16.60 | 0. | 0. | 0. | 0. | 3.60E+02 | 3 | 0. |
| Generalized Source S | -1.34 | -4.65 | -4.79 | 0. | 0. | 0. | 0. | 0. | 3 | 0. |
| Generalized Source N | -1.34 | -1.43 | -1.74 | 0. | 0. | 0. | 0. | 3.72E+02 | 3 | 0. |
| Generalized Source W | -6.21 | -1.34 | -1.74 | 0. | 0. | 0. | 0. | 2.33E+02 | 3 | 0. |
| 4. Post-Operational (Proposed Sand/Clay Cap Reclamation) |  |  |  |  |  |  |  |  |  |  |
| Generalized Source E | 2.59 | -0.85 | 16.60 | 0. | 0. | 0. | 0. | 8.10E+02 | 3 | 0. |
| Generalized Source S | -1.34 | -4.65 | -4.79 | 0. | 0. | 0. | 0. | 1.35E+02 | 3 | 0. |
| Generalized Source N | -1.34 | -1.43 | -1.74 | 0. | 0. | 0. | 0. | 1.95E+02 | 3 | 0. |
| Generalized Source W | -6.21 | -1.34 | -1.74 | 0. | 0. | 0. | 0. | 1.50E+02 | 3 | 0. |

[a] Particle Size and Fractional Distribution

| Set | 1.0 | 1.0 | 5.0 | 35.0 | Density ($g/cm^3$) |
|---|---|---|---|---|---|
| 1 | 1.000 | 0.000 | 0.000 | 0.000 | 8.900 |
| 2 | 0.000 | 1.000 | 0.000 | 0.000 | 2.400 |
| 3 | 0.000 | 0.000 | 0.300 | 0.700 | 2.400 |

# TABLE V B-14
# POPULATION DISTRIBUTION USED TO CALCULATE DOSE COMMITMENTS

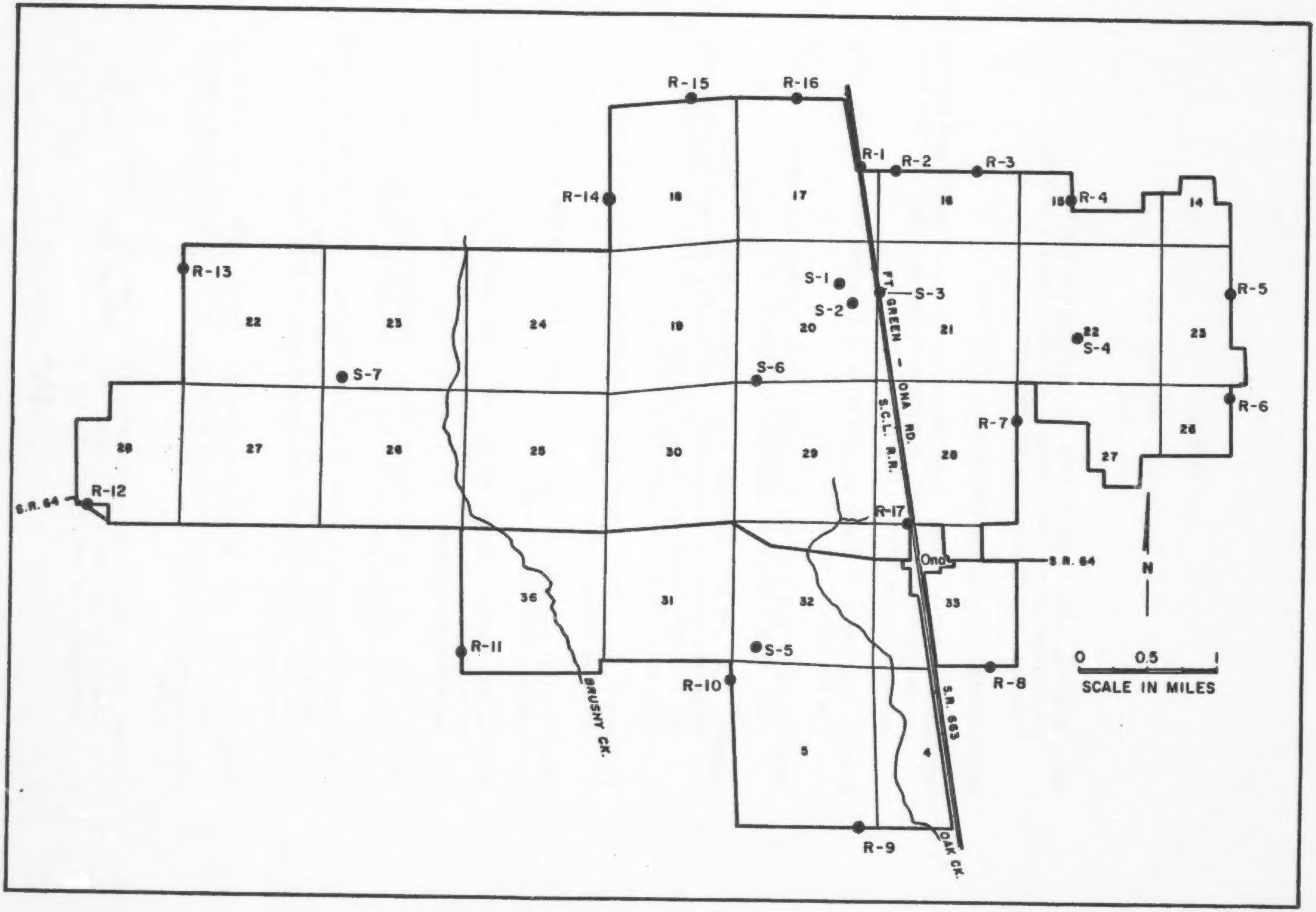
REGION=MCC HARDEE COUNTY MINE
METSET=ONA, FLORIDA

CODE=MILDOS,REVO (7/79)

DATE= 03/18/81.
PAGE NO. 4

| KILOMETERS | N<br>0.0 | NNE<br>22.5 | NE<br>45.0 | ENE<br>67.5 | E<br>90.0 | ESE<br>112.5 | SE<br>135.0 | SSE<br>157.5 | S<br>180.0 | SSW<br>202.5 | SW<br>225.0 | WSW<br>247.5 | W<br>270.0 | WNW<br>292.5 | NW<br>315.0 | NNW<br>337.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0- 2.0 | 0 | 0 | 3 | 15 | 8 | 8 | 5 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.0- 3.0 | 0 | 0 | 0 | 15 | 30 | 25 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0- 4.0 | 0 | 0 | 0 | 40 | 43 | 98 | 20 | 0 | 0 | 0 | 13 | 8 | 0 | 0 | 0 | 0 |
| 4.0- 5.0 | 58 | 0 | 15 | 60 | 35 | 13 | 8 | 0 | 0 | 3 | 3 | 23 | 5 | 0 | 0 | 0 |
| 5.0-10.0 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 |
| 10.0-20.0 | 433 | 2208 | 433 | 3885 | 1762 | 433 | 433 | 433 | 433 | 433 | 433 | 2812 | 2812 | 2812 | 2812 | 2097 |
| 20.0-30.0 | 3437 | 3437 | 709 | 709 | 709 | 709 | 709 | 755 | 755 | 755 | 4610 | 4610 | 4610 | 4610 | 12112 | 3437 |
| 30.0-40.0 | 4813 | 9497 | 4813 | 993 | 993 | 993 | 1058 | 7149 | 1058 | 1058 | 6454 | 6454 | 6454 | 6454 | 16957 | 4813 |
| 40.0-50.0 | 22690 | 6167 | 9172 | 14286 | 2042 | 2042 | 1356 | 1356 | 1356 | 13895 | 8270 | 13895 | 8270 | 21728 | 21728 | 2172 |
| 50.0-60.0 | 7725 | 12970 | 16741 | 7563 | 30856 | 2505 | 1663 | 1663 | 5617 | 17040 | 17040 | 17040 | 10142 | 26647 | 26647 | 26647 |
| 60.0-70.0 | 61838 | 12575 | 8938 | 8938 | 2960 | 3889 | 2960 | 6639 | 14617 | 11931 | 20139 | 71162 | 15232 | 31492 | 31492 | 47528 |
| 70.0-80.0 | 10703 | 23566 | 10314 | 10314 | 3416 | 3416 | 677 | 7660 | 7660 | 7660 | 23237 | 23237 | 32201 | 36337 | 36337 | 36337 |
| 1.0-80.0 | 111803 | 70526 | 51244 | 46924 | 42960 | 14237 | 9005 | 25821 | 31602 | 52881 | 80305 | 139347 | 79832 | 130186 | 148191 | 123137 |

TOTAL 1-80 KM POPULATION IS1158001 PERSONS


R-15
R-16
R-1
R-2
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R-6
R-7
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R-10
R-11
R-12
R-13
R-14
R-17
S-1
S-2
S-3
S-4
S-5
S-6
S-7
FT. GREEN – ONA RD.
S.C.L. R.R.
S.R. 663
S.R. 64
Ona
OAK CK.
BRUSHY CK.
N
0
0.5
1
SCALE IN MILES
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
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31
32
33
36
4
5

Figure V B-1. Location of Sources and Receptors of Airborne Radioactivity.

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